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Modeling Department of Defense controlled atmosphere transshipments for forward deployed forces

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THESIS

MODELING DEPARTMENT OF DEFENSE CONTROLLED ATMOSPHERE TRANSSHIPMENTS FOR FORWARD DEPLOYED FORCES

by

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The objective of this thesis is to explore the cost savings, product quality improvement, and process efficiencies that can be realized by the integrated design and application of an innovative logistics system for the purchase and transshipment of fresh fruits and vegetables (FFV) to forward deployed units.

The expanding global marketplace, strategic partnerships with private industry, aggressive utilization of commercial-off-the-shelf (COTS) technology, and an aggregate understanding of the logistics pipeline process will enable the Department of Defense (DoD) logistician to provide the customer with a wider variety of fresher, higher quality product, while exploiting monetary savings through competitive pricing, lower transportation costs, and reduced product handling losses and damage.

The aggressive application of this process can result in the wholescale shift of the current operational paradigm with regards to the support of forward deployed forces, from the sea. Combat Logistic Forces will have increased flexibility for scheduling and ultimately expand their operational capability, remaining at sea for longer periods of time, carrying more product, and better serving the warfighter.

A summary of findings is provided with recommendations for further research into specific applications of technologies, training, and existing processes.

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MODELING DEPARTMENT OF DEFENSE CONTROLLED ATMOSPHERE TRANSSHIPMENTS FOR FORWARD DEPLOYED FORCES

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MASTER OF SCIENCE IN MANAGEMENT

ABSTRACT

The objective of this thesis is to explore the cost savings, product quality improvement, and process efficiencies that can be realized by the integrated design and application of an innovative logistics system for the purchase and transshipment of fresh fruits and vegetables (FFV) to forward deployed units.

The expanding global marketplace, strategic partnerships with private industry, aggressive utilization of commercial-off-the-shelf (COTS) technology, and an aggregate understanding of the logistics pipeline process will enable the Department of Defense (DoD) logistician to provide the customer with a wider variety of fresher, higher quality product, while exploiting monetary savings through competitive pricing, lower transportation costs, and reduced product handling losses and damage.

The aggressive application of this process can result in the wholescale shift of the current operational paradigm with regards to the support of forward deployed forces, from the sea. Combat Logistic Forces will have increased flexibility for scheduling and ultimately expand their operational capability, remaining at sea for longer periods of time, carrying more product, and better serving the warfighter.

A summary of findings is provided with recommendations for further research into specific applications of technologies, training, and existing processes.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKROUND

The United States Navy, in the execution of its operating tenants of global presence and power projection, keeps naval combatants and support and auxiliary vessels deployed and operating continuously around the world. Maintaining deployed forces at the highest levels of operational readiness via a strategic resupply plan is a key to success for the Armed Forces logistician. The Department of Defense (DOD) procures, stores and ships a variety of product lines to overseas locations in support of customers ashore and forward deployed units. For Naval vessels, many commodities are replenished either at sea or during brief port visits to minimize a unit's time away from operating station.

DOD supply commands have engaged continually in move-store activities. This thesis will explore the concept of coordinated management of all related resupply activities. Analysis will focus on integration of individual activities and the trade-off implications associated with customer service standards.

The commodity examined herein is fresh fruits and vegetables (FFV). Issues such as controlled atmosphere containers benefit to highest use product lines, proper temperature control, compatible gas mixtures and appropriate fumigation requirements are investigated. Current commercial and

DOD practices and private industry solutions are examined, and recommendations are offered for the most effective DOD strategy.

B. OBJECTIVES

The objective of this thesis is to determine the best process and to develop a model for transporting selected interrelated product lines, primarily fresh fruits and vegetables, to forward deployed customers. Current and emerging technologies and their effects on cost benefits, source purchasing and operational paradigms are examined.

C. RESEARCH QUESTIONS

DOD procures and ships a variety of product lines to overseas locations to support customers ashore and forward deployed forces. Additional procurement takes place in areas outside of the continental United States (CONUS) and at other areas of operation. This thesis focuses on current procedures and policies used in daily operations and analyzes the overall strategies used to deliver fresh fruits and vegetables to the forward deployed military customer. Questions addressed include the following.

1. What are the current processes for shipment of FFV to forward deployed units? There are several avenues currently in use to transport FFV to the customer. Operating areas and schedules play a role in determining what method is utilized. A global approach will be taken to this initial question and then regions will be developed to address many of the questions remaining.

2. **How well do these processes work? What are the sources of problems in the current processes?** Each process has experienced both successes and difficulties in terms of providing the best quality product at a reasonable cost to forward deployed customers. The strengths and weaknesses of each process will be examined.

3. **What are the current order and shipping times?** The amount of time between when the customer must place the order and the time the order is actually delivered/picked up is examined for each operating area.

4. **What FFV product lines are utilized by forward deployed units? What quantities of these product lines are ordered?** The top twenty products, ranked by total quantity ordered will be sought. If these line items do not account for the majority of produce ordered, additional items will be considered.

5. **Who are the major seasonal producers of FFV product lines?** Various products are in season in different parts of the world at all times. This impacts availability to the end user both due to cost and transportation/freshness constraints. The major producers/shippers for each product line during each harvest season will be identified.

6. **What is controlled/modified atmosphere (CA/MA)?** This technology will be introduced and discussed as it is currently utilized.

7. **Will CA/MA enable delivery of acceptable product quality for DOD customers?** Will CA/MA enable transshipment via sealift vice airlift? The ability to transform current commercial practices into something DOD can benefit from will be researched. DOD initiatives in CA/MA will be discussed. If the technology is applicable to DOD, the ability to use alternate shipment methods by employing this CA/MA principles will be explored.

8. **Is controlled atmosphere technology applicable to shipboard storage aboard U.S. Navy ships?** Are there any benefits to be gained by utilizing CA/MA on board ships, both Combat Logistics Force ships and combatants? Exploration of whether or not this technology can be used on board ships to effectively extend useable life and quality of FFV once shipboard will be done. Methods of implementing CA/MA on board ships will be examined if it is determined to be a viable option. From a Combat Logistics Force perspective, CA/MA will be looked at as a means to preserve quality and freshness of FFV until delivery to customer units.

9. **Where are FFV purchased for DOD customers?** Host nation and United States laws, politics, available commodities/growing

regions and seasons and DOD regulations dictate the sources for FFV procurement. Common sources of procurement for FFV will be identified and discussed.

10. What forecasting techniques are utilized for forward deployed FFV requirements? Current guidance and practice will be explained.

11. Is customer service being measured? If so, how? Each process for providing FFV to end use customers has an associated service level. Components of service level such as required delivery date reliability, spoilage and damage will be researched.

D. SCOPE, LIMITATIONS, AND ASSUMPTIONS

The scope of this thesis will include the following major subject areas:

1. Research on the organizational structure of Defense Logistics Agency (DLA), Defense Support Center, Philadelphia (DSCP) and Defense Subsistence Office (DSO) and relationships to operational and logistics support staffs. Who sets policy, what are the current procedures and issues involved in shipping FFV to forward deployed customers? What product lines are most utilized?

2. A review of current CA/MA technology to include private industry and DOD utilization to date. What is CA/MA and what are the benefits to be gained? How can DOD use CA/MA technology? What product lines are compatible when using CA/MA? What can be learned from the private sector and applied to similar operations?

3. Review of current customer service standards and areas of possible improvement. How much FFV has been lost to spoilage on board deployed units and while in transit to them? Do current methods meet customer service requirements as measured by adherence to required delivery dates, order lead time and acceptable quality and variety levels. What metrics are used to measure customer service? Are the correct metrics being measured? What are the optimum and average levels and range of customer service being provided?

4. Development of a model process for resupply of FFV to deployed units. What methods should be utilized to get the best products at the best price to the customer?

Currently, several initiatives are under consideration that could impact the outcome of the research. These include the Prime Vendor program and the increased role being sought by DSCP in support of deployed vessels in some geographic locations historically supported via alternate means. Both current procedures and proposed procedures will be addressed.

E. LITERATURE REVIEW AND METHODOLOGY

In conducting research for this thesis, a review of policies and procedures, current and emerging technologies, transportation methods and appropriate statistics will be gathered by conducting personal and telephone interviews, written correspondence and use of applicable academic articles, trade journals and publications and instructions. Information from the following DOD sources will be included in this thesis:

- Defense Logistics Agency
- Naval Supply Systems Command
- DSCP Headquarters
- DSCP Pacific Region
- DSCP Europe Region
- Defense Subsistence Officer, San Francisco
- Naval Regional Contracting Center, Naples
- Naval Regional Contracting Center, Bahrain det.
- United States Transportation Command, including component commanders:
- Military Sealift Command
- Air Mobility Command
- Military Traffic Management Command
- United States Department of Agriculture
- United States Department of Transportation

Commercial sources of information include the following companies and organizations:

- Armin CAB, Inc.
- OOCL, Inc.
- Chiquita International
- The GIC Group
- Nitec Inc.
- Thermo King Inc.
- P.E.B. Commodities, Inc.
- TransFRESH
- University of California, Davis
- California Department of Food and Agriculture
- National Defense Transportation Association
- American Presidents Line
- SeaLand
- Carrier Transicold
- Ethylene Control, Inc.
- Environmental Friendly Products, Inc.
- Paramount Exporters
- Permea, Inc.
- Maersk Shipping Lines
- Carlisle Container Manufacturing
- Gelco Enterprises
- International Society of Logistics (SOLE)

- Hyundai Precision

Current practices and regional differences make a geographic approach the most beneficial. Once practices are identified, each region will be addressed singularly.

F. ORGANIZATION OF STUDY

The organization of this thesis will begin with a comprehensive review of DOD commands involved in the FFV shipment process in Chapter II. Chapter III will provide a foundation for further exploration through discussion of material distribution procedures, product lines, controlled atmosphere, modified atmosphere, ethylene absorbing products and customer service levels.

A cost analysis between DOD and the private sector for shipping CA containers will be discussed in Chapter IV.

Application of research to forward deployed units is addressed in Chapter V. This includes a discussion of global sourcing, van load configurations and parameters, operational constraints and applicability of CA/MA and ethylene absorbing products to naval vessels.

Conclusions derived from the research will be cited in Chapter VI as well as recommendations for further research.

II. DEPARTMENT OF DEFENSE LOGISTICS

A. INTRODUCTION

The Defense Logistics Agency (DLA) is a combat support agency whose primary mission is to provide supply support, contract administration services and technical and logistics services to all branches of the United States Armed Forces. The United States Transportation Command (TRANSCOM) is the single manager of the Defense Transportation System (DTS). DLA and TRANSCOM, through the operational responsibilities of their subordinate directorates and agencies, procure, ship, store, and distribute supply support throughout the world in an integrated logistics pipeline. The following section will discuss the origins of modern defense-related supply and distribution systems and the key milestones that have ultimately resulted in the present day relationships that enable procurement, supply, and distribution of subsistence products to Armed Forces personnel worldwide.

B. HISTORICAL PERSPECTIVE

Against the backdrop of the armistice that signaled the end of World War II, President Harry S. Truman convened a presidential commission chaired by former President Herbert Hoover, that among other things, recommended centralizing management of common military logistics support. [Ref.1] This particular recommendation was realized in 1952 with the establishment of a combined Navy-Army-Air Force Support Center that integrated the management of supplies by procuring, storing and distributing products using a common nomenclature. The DOD and individual services defined the common materials to be managed as an integrated product as "consumables" i.e., products that are not repairable or consumed during their intended use. In satisfying the mandate for integrated management for consumables, individual services were assigned commodity groups and designated the commodity - manager agency for all of DOD. From 1954-1956 the Army operated as commodity manager for food and clothing, Navy managed medical supplies, petroleum, oil and lubricants (POL) and industrial parts, as the Air Force managed electronic items. During this time period, the commodity manager concept proved that a single agency could efficiently procure, issue, store, forecast requirements and manage inventories across service boundaries and realize significant economies of scale while doing so. The commodity-manager agency was not without limitations. Foremost were the use of service specific procedures by each agency within its own operations. The result was three different systems/procedures for three commodity-manager systems. Responding to this systemic inefficiency then Secretary of Defense, Robert McNamara, ordered the consolidation of the various commodity-manager agencies into one entity. On 01 OCT 1961, the Defense Supply Agency (DSA) was established, and on 01 JAN 1962, eight commodity-manager agencies consolidated and began operating as DSA. [Ref.2] In 1965 DSA consolidated the operations of three supply centers; the Defense Subsistence Supply Center, Defense Clothing Supply Center, and the Defense Medical Supply Center into a single supply center designated the Defense Personnel Support Center (DPSC), Philadelphia, PA.

In 1973, DSA expanded their scope of operations to cover worldwide commitments of the U.S. Armed Forces and were assigned responsibility for overseas wholesale food stocks and bulk fuel stocks. DSA was redesignated the Defense Logistics Agency (DLA) in 1977 to accurately reflect both the heightened awareness of logistics as an independent discipline and the agency's expanding role in worldwide DOD commitments. [Ref.3]

The last major restructuring of DLA was directed by then Secretary of Defense, Richard Cheney, who directed that all the distribution depots of the military services and DLA merge into a single, unified material distribution system, designating DLA to manage it. The consolidation began in October 1990 and was completed 16 March 1992. [Ref.4]

> The Defense Logistics Agency is a combat support agency. It provides material and supplies to the military services and supports their acquisition of weapons and other equipment. DLA buys and manages a vast number and variety of items used by all of the military services and some civilian agencies. The military services determine their requirements for

> supplies and material and establish the priorities. DLA supply centers consolidate the services requirements and procure the supplies in sufficient quantities to meet the services' projected needs. [Ref.5]

One of the nine commodity areas DLA manages is food. Product lines making up this commodity area are purchased, and either delivered directly from a commercial vendor inducted as inventory and distributed through Supply Centers and Defense Distribution Centers. By DLA definition, subsistence supply requires purchasing food fresh, canned, frozen or dehydrated for use in dining halls and field units and for resale in military commissaries. [Ref.6] Food must be of the highest quality because it may be served in a variety of locations including; overseas bases, in submarines or in the field. The food must be packaged and transported in a manner that retains it's attractiveness and nutritional content.

C. DEFENSE PERSONNEL SUPPORT CENTER

In addition to establishing the precursor to the Defense Logistics Agency, the Hoover Commission recommended the establishment of a centralized perishable food management organization. The resulting commodity-management agency, the Market Center System (MCS), was established under the authority of the Army Quartermaster Corps (QMC). This organization sought and hired high quality experts from industry (i.e., Kroeger and Winn-Dixie) to serve as buyers and managers, supplementing Army personnel. [Ref.7] The MCS concept was highly successful, demonstrating tangible cost savings and efficiencies, and was rapidly expanded in the late 1940's and early 1950's to eventually encompass eleven regional quarter master MCSs. In 1953, an initiative to centralize the procurement of semi-perishable product lines and operational rations was implemented and resulted in the establishment of the Defense Subsistence Supply Center (DSSC) in Chicago, IL. [Ref.8] While the DSSC consolidated procurement for semi/non-perishable goods and operational rations, the procurement of perishable goods was "spun-off" to eight decentralized regional centers.

In the 1960's, the Defense Supply Agency consolidated clothing, subsistence and medical supplies procurement operations to form the Defense Personnel Support Center (DPSC) in Philadelphia, PA. The Defense Personnel Support Centers (DPSC) are the distribution vehicle through which subsistence is procured, stored and distributed to U.S. Armed Forces Personnel worldwide. The next several decades brought increased responsibility, commitments and consolidations, such that, by 1985, DLA provided worldwide subsistence support through three Defense Personnel Support Center Regions (DPSCRs): DPSCs in Philadelphia, PA, Alameda, CA, and Wiesbaden, Germany. Figure 1 illustrates the formal chain of command between DLA and DPSC.

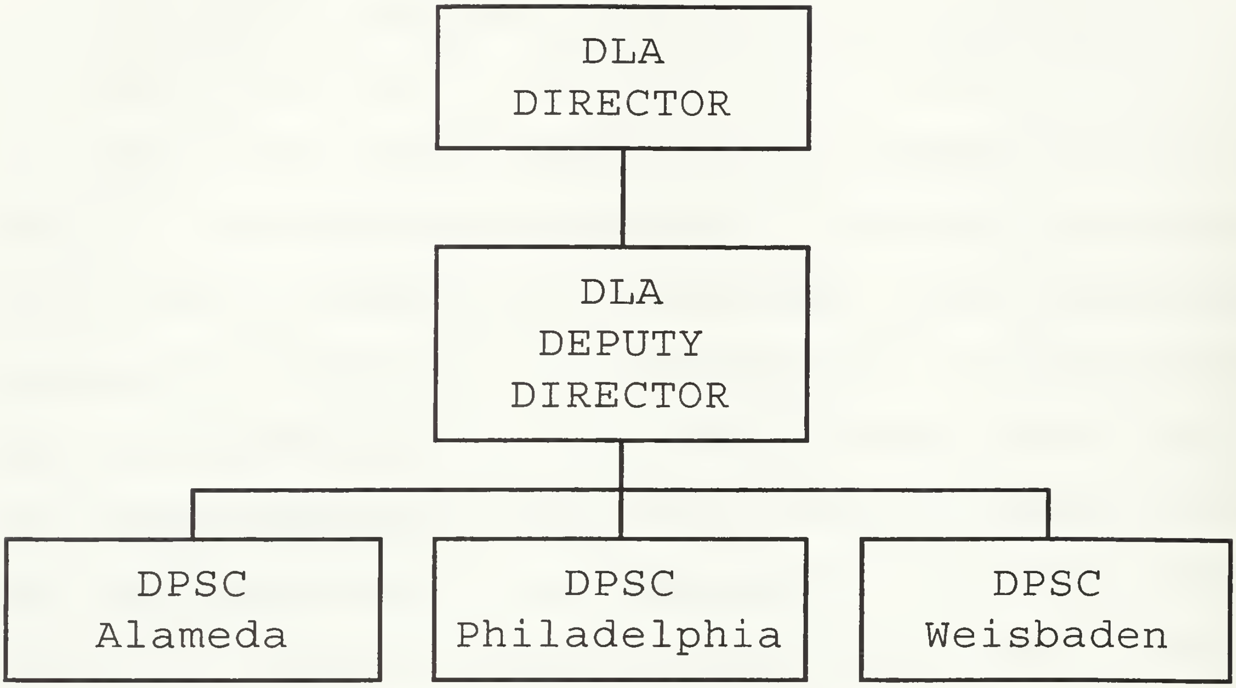

FIGURE 1: DEFENSE LOGISTICS AGENCY (PRE-1998)

DPSC Atlantic Region serves 110 ships of the Atlantic Fleet in addition to nine major naval installations, four additional DOD organizations and non-DOD Government customers such as Veterans Administration, Bureau of Federal Prisons and Native American Reservations. DPSC Pacific Region serves 388 total customers including 182 ships of the Pacific Fleet, while DPSC Europe serves 178 customers of which 30 are ships of the United States Sixth Fleet. These three DPSCs are responsible for worldwide support in the procurement, delivery storage and quality assurance of subsistence to meet the demand of their respective regional customers.

As a direct result of the Base Realignment and Closure (BRAC) Commission's decision of 27 June 1993 to close various government facilities, including specific Philadelphia area installations, several consolidations, relocations and disestablishments contribute to the makeup and function of the Defense Supply Center Philadelphia (DSCP). On 28 September 1995, BRAC 95 became official resulting in the disestablishment of the Defense Industrial Supply Center (DISC, responsible for the procurement and supply of the military services industrial hardware items) in Northeast Philadelphia, delay of the DPSC relocation to the Navy Inventory Control Point (NAVICP) compound, and creation of a new ICP in Philadelphia to manage troop and general supply items.[Ref.9] To comply with BRAC 95 law, DPSC was renamed DSCP on 13 January 1998, and combined the procurement and supply functions of DPSC's subsistence commodities with the procurement, supply, and distribution responsibilities of DISC's industrial hardware commodity groups. Figure 2 graphically illustrates the organizational lines of authority reflecting the most recent reorganization.

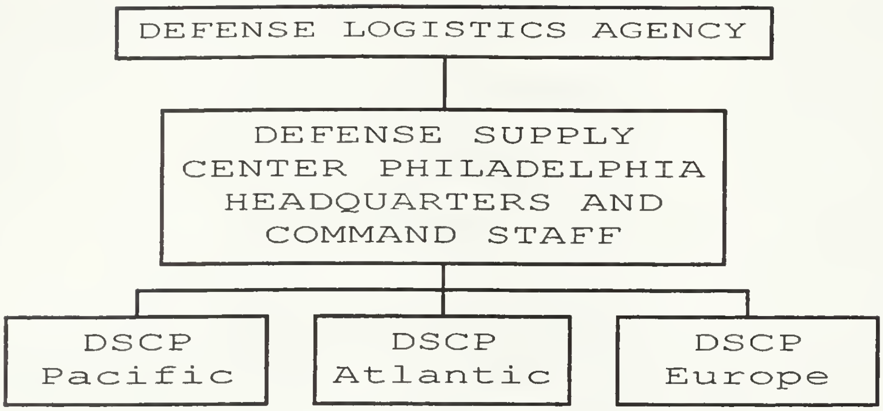

FIGURE 2: DSCP ORGANIZATION (ESTABLISHED 13 JANUARY 1998)

Each regional DSCP; DSCP-Atlantic, (including a command and headquarters component) DSCP-Pacific and DSCP-Europe is composed of several directorates with specific commodity responsibilities such as subsistence, clothing and textiles, and Medical supplies. These relationships are depicted in Figure 3.

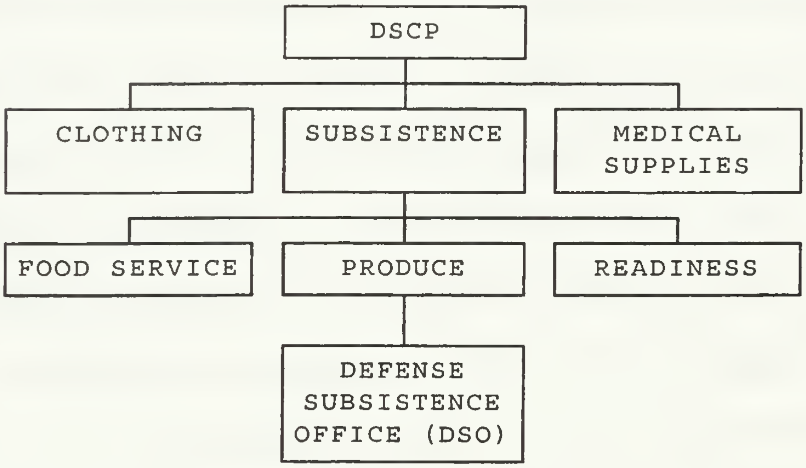

FIGURE 3: DSCP DIRECTORATES OF COMMODITY BUSINESS UNITS

DSCP's subsistence directorate is made up of three Commodity Business Units (CBU); Food Service, Produce and Readiness. DSCP's Produce CBU's, in general terms;

> ...provides perishable food support and services to the military services, the Defense Commissary Agency (DeCA), U.S. Department of Agriculture, Military Exchanges, and other government agencies within the continental United States; export support and services to overseas military installations and DeCA commissaries. Directs DSCP field buying activities for fresh fruit and vegetables, as well as managing commercial cold storage warehouse contracts and budgets. [Ref.10]

Subordinate to the regional DPSC and responsible for the procurement, storage, and distribution of specific perishable product lines are twenty-six Defense Subsistence Offices (DSO). To enable the efficient oversight of perishable subsistence commodities such as fresh fruit and vegetables (FFV), twenty-six food buying activities, DSO's, operate under the direction of DSCP. DSOs specialize in the procurement and distribution of fresh fruit and vegetables (FFV) and less-than-carload quantities of chilled and frozen product lines.

D. DEFENSE TRANSPORTATION SYSTEM

As a direct result of a chaotic command post exercise in the fall of 1978, designated Nifty Nugget, tremendous shortfalls were exposed during a simulated full-scale mobilization in the support of NATO following a Warsaw Pact attack. Among the myriad of recommendations and lessons learned published in the aftermath of Nifty Nugget was that the individual services Transportation Operating Agencies (TAO), later Transportation Component Commands (TCC), should report directly to the Joint

Chiefs of Staff (JCS) and that they designate a single overarching manager for all defense transportation requirements. [Ref.11] In June, 1979, the Chairman of the (JCS) stood up the Joint Deployment Agency (JDA) and charged it with the mission of acting as the single point of contract, with direct access to him, for the deployment and execution of all defense mobilization. [Ref.12] DOD, however, still needed to consolidate transportation services. The President's Blue Ribbon Commission on Defense Management, known as the Packard Commission, recommended that "the Secretary of Defense should establish a single unified command to integrate global air, land and sea transport." [Ref.13] President Ronald Reagan signed National Security Decision Directive (NSDD) No. 219 on 01 April 1986. In NSDD No. 219, the President stated:

> I also support the recommendation of the Packard Commission that the current statutory prohibition on the establishment of a single unified command for transportation be repealed. Assuming this provision of law will be repealed, the Secretary of Defense will take these steps necessary to establish a single
>
> unified command to provide global air, land and sea transportation. [Ref.14]

As part of the Goldwater-Nichols Department of Defense Reorganization Act of 1986, the United States Transportation Command (USTRANSCOM) was established. [Ref.15] Originally USTRANSCOM was designated a wartime-oriented command charged with the coordination of wartime-related transportation services and traffic management issues. In 1991, following the Desert Shield/Desert Storm mobilization and deployment, all references limiting USTRANSCOM to wartime related activities were eliminated from the commands charter. Also in 1991, the Secretary of Defense designated USTRANSCOM as the combatant commander of common use transportation resources, and as the single manager for defense transportation in peace and war. [Ref.16] In his fiscal year 1998 Defense Posture Statement (DPS) to the Senate Armed Forces Committee, General Walter Kross, Commander-in-Chief, USTRANSCOM (CINCTRANS) stated:

> As the sole operator of DOD's strategic transportation system, USTRANSCOM provides the end-to-end transportation support so essential to an operation's success. The command's activities extend well beyond transportation, however. USTRANSCOM is heavily involved in development of leading edge information Systems for better transportation management, oversight and management of important quality of life initiatives for our men and women in uniform and reengineering of the acquisition process which provide the vital links to the commercial industry. [Ref.17]

USTRANSCOM accomplishes its mission of managing the Defense Transportation System (DTS) through utilization of three major component commands; Air Mobility Command (AMC), Military Sealift Command (MSC) and Military Traffic Management Command (MTMC). Each component command operates as an autonomous organization with respect to their parent services, and, under the umbrella of USTRANSCOM make up the DTS.

AMC Headquarters at Scott AFB, Illinois, is the single manager for and provides USTRANSCOM with the airlift component of the DTS. Additionally, AMC provides aeromedical evacuation , special air missions and air-to-air refueling to enable the global reach of air mobility. AMC currently operates 516 airlift and aerial refueling/airlift aircraft while the National Guard and Air Force Reserve (USAFR) combine to operate 673 airlift and airlift/aerial refueling aircraft. As robust as this global fleet seems, AMC carries only 10 percent of all DOD long-range passenger travel and 60 percent of long-range cargo shipment. [Ref.18] Augmenting government owned assets during both peace-time and contingency/war-time operations are the aircraft of the Civil Reserve Air Fleet (CRAF). CRAF assets are civilian owned aircraft from U.S. flagged air transport companies. These aircraft are contractually committed to support AMC airlift requirement when airlift demand exceeds AMC organic asset capability. To provide incentives for civil carriers to commit these aircraft to the CRAF program and to assure the United States adequate airlift reserves, AMC awards peacetime airlift contracts to civilian airlines which offer aircraft to CRAF. For Fiscal Year (FY) 1997 the aggregate guaranteed portion of all CRAF contracts totaled 334 million dollars with an additional 260 million dollars worth of services contracted for that was not guaranteed. [Ref.19] CRAF has three sections; Long Range International (LRI) that require transoceanic aircraft capable of augmenting AMC long-range airlifters, the Short Range (SR) aircraft consist of medium-size aircraft augmenting AMC theater airlift assets, and Aeromedical Evacuation (AE) aircraft augmenting AMC air ambulance assets.

The mission of the Military Sealift Command (MSC) is to provide ocean transportation of equipment, fuel, supplies and ammunition to sustain U.S. forces worldwide during peacetime and in war for as long as operational requirements dictate. [Ref.20] MSC operates as the sealift component commander for USTRANSCOM and, as such, is responsible for the coordination of all common-use DOD ocean-based transportation worldwide. Organic dry-cargo assets available for a surge mobilization total 86 vessels, therefore it is DOD policy to rely on commercial sealift to fill the difference between demand and availability. In peacetime more than 95 percent of DOD dry cargo is shipped on commercial vessels. While estimates vary, it is theorized that for sustainment purposes, commercial sealift would be utilized for between 90 and 95 percent of total sealift capacity. [Ref.21] In the event of a full mobilization, more than 1,000 ships and 30,000 people would be employed in sealift missions ashore and afloat. [Ref.22] The Voluntary Intermodal Sealift Agreement (VISA), a partnership between the U.S. Government and industry, was introduced in the mid 1990's to provide joint planning and assured access to commercial shipping during a national emergency. The agreement makes it possible for the U.S. DOD to use the ships and shore-based transportation systems of ocean shipping companies which receive a subsidy from the Federal Government or are awarded peacetime defense cargo movement contracts. [Ref.23] Additional programs and initiatives include the Maritime Security Program (MSP) and the Joint Planning Advisory Group (JPAG) which help preserve the required base of merchant seaman available to operated DOD-owned sealift and identify, plan for and meet VISA requirements, respectively.

CRAF, VISA and MSP provide proof that every government contract which procures transportation services offers the possibility of leverage to secure wartime commitments from commercial industry. As the single manager of the DTS, USTRANSCOM has sufficient insight into and appropriate influence on all contractual arrangements between DOD and private industry regarding transportation services. [Ref.24]

The Military Traffic Management Command (MTMC) is the primary traffic manager and overland lift component commander for USTRANSCOM. MTMC's Joint Traffic Management Office (JTMO) coordinates DTS's surface intermodal movements for both domestic and international freight, cargo and containers. By combining specific command elements of MSC and MTMC, it acts as the single point of contract for purchasing authority and services. MTMC executes and works for continual improvement in four core competencies; global traffic management, integrated transportation systems, deployability engineering, and worldwide port operations. MTMC acts as the sole interface between DOD asset shippers and contract commercial carriers. Through the Worldwide Port System (WPS), MTMC sustains port operations in 68 sites throughout the Continental U.S. (CONUS), Europe and the Western Pacific (WESTPAC), including 25 seaports worldwide.

In summary, DLA supports the worldwide sustainment and resupply of forward deployed Armed Forces personnel. Specifically, when a requirement for a subsistence commodity such as fresh fruit and vegetables exists, DLA satisfies that requirement through the efforts of subordinate regional commands like DSCPs and DSOs. USTRANSCOM, through its component commands, AMC, MSC, and MTMC, is responsible to the Chairman of the JCS, for the timely movement of commodities from the point of origin to the end-use customer anywhere in the world. The transport may involve organic assets within the DTS or contracted commercial services negotiated through long-term agreements and partnerships. In the following chapters we will discuss how value can be added to this integrated process, through innovative business practices, commercial-off-the-shelf (COTS) technology and the application of an aggressive supply chain management vision.

III. COMMODITY DISTRIBUTION

A. MATERIAL DISTRIBUTION PROCEDURES AND LIMITATIONS

The United States Navy is organized into five fleets defined by operating area. Figure 4 graphically depicts these geographic AORs. These include the Second Fleet headquartered in Norfolk, Virginia, whose Area Of Responsibility (AOR) is the Atlantic Ocean, the Third Fleet headquartered in Pearl Harbor, Hawaii whose AOR is the eastern Pacific Ocean, the Fifth Fleet headquartered in

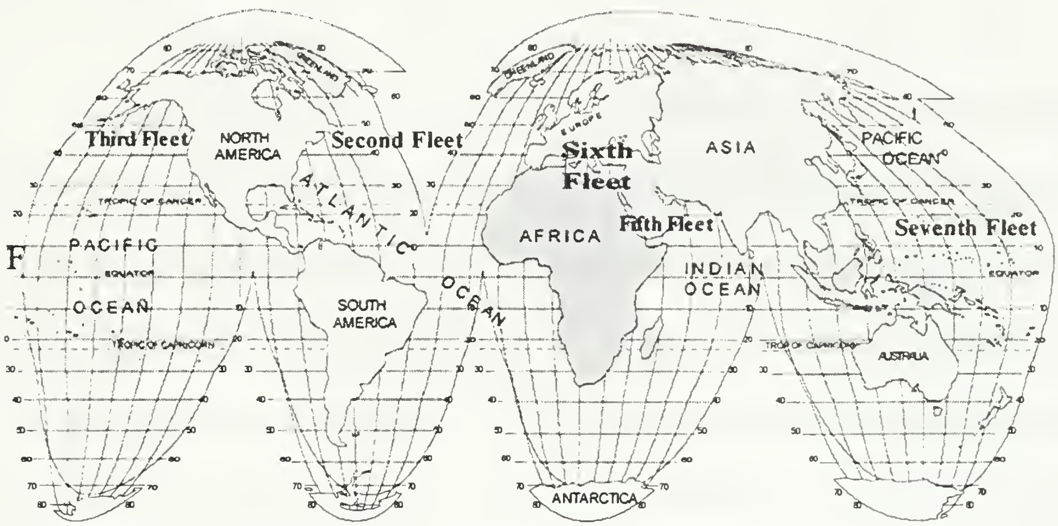

FIGURE 4: GEOGRAPHIC LOCATION OF U.S. NAVY FLEETS

Manama, Bahrain whose AOR is the Arabian Gulf/Persian Gulf and Middle East regions, the Sixth Fleet headquartered in Gaeta, Italy whose AOR is the Mediterranean Sea, Black Sea and Europe, and the Seventh Fleet headquartered in Yokosuka, Japan whose AOR is the western Pacific Ocean/far east regions. For the purposes of this discussion, forward deployed units, units deployed away from their homeports for at least sixty days, can originate from any one of the Numbered Fleets. Typically, Second Fleet units rotate forward to the Fifth and Sixth Fleets while Third Fleet units rotate forward to the Fifth and Seventh Fleets. These Changes in Operating Areas (CHOP) not only represent the strategic and tactical movement of forces amongst the Fleet's Area of Responsibility (AOR), but also result in a change of cognizance for logistics support for the unit. For example, when a Second Fleet unit CHOPs into the Mediterranean AOR, Sixth Fleet not only utilizes the unit in the accomplishment of its mission, but also accepts responsibility for the refueling, rearming and resupply of the unit for the duration of the deployment. In theory, any Numbered Fleet's Naval unit afloat could forward deploy or CHOP to any other Numbered Fleet, but for the majority of practical matters, Second and Third Fleet units rotate forward to Fifth, Sixth and Seventh Fleet AORs.

The ordering and distribution procedures for the Fifth, Sixth, and Seventh Fleet with regards to FFV are tailored to the AORs logistical support structure and availability of commodities within each region and thus may vary depending on the region. Orders are placed based upon the number of days of shelf life expected upon delivery, a concern that directly impacts order size and order placement date for each of the procedures used. Requirements are determined by each ship individually based on the cycle menu in use during deployment. Review and updating of the cycle menu is highly recommended prior to deployment to ensure commodities needed are available in the AOR.

1. Fifth Fleet

a. *Procedures*

The procurement of FFV in Fifth Fleet is governed by a series of contracts managed by NRCC Naples, Bahrain Detachment and procedures promulgated by the Administrative Support Unit, Southwest Asia, Bahrain. [Ref. 11] Orders are submitted as part of the Logistics Requirements (LOGREQ) messages submitted by individual ships prior to the unit entering port. Price is cited on each contract. Contracts are updated at least yearly. Depending on location, some are updated every six months.

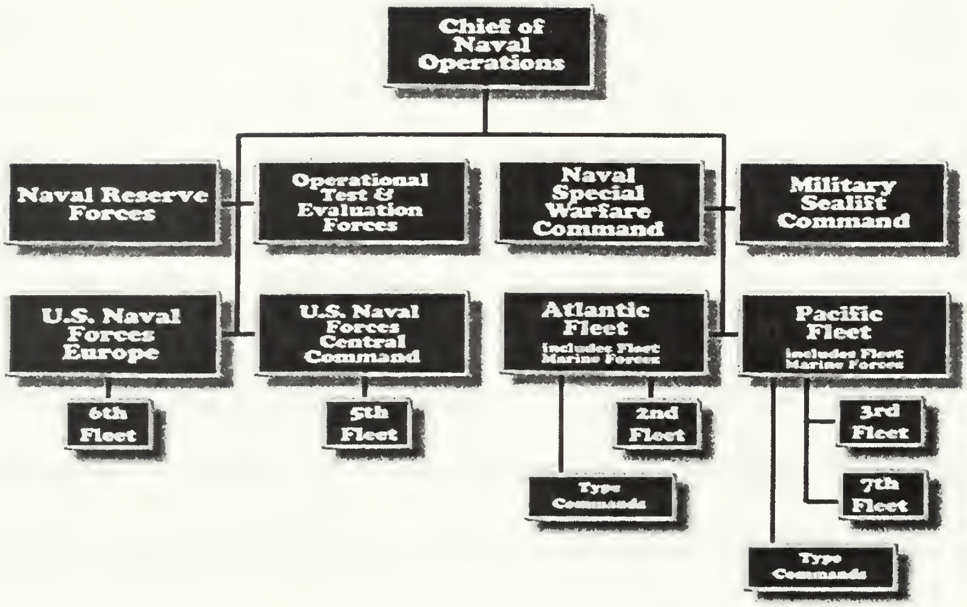

FIGURE 5: U.S. NAVY FLEET CHAIN OF COMMAND

As depicted in Figure Five, the support activity responsible for logistics support for visiting ships and administrative and operational LOGREQ response is determined by the location of the port of call. For example, visits to Dubai, Abu Dhabi and Fujairah, United Arab Emirates are monitored by the United States Defense Attaché Office (USDAO) Abu Dhabi [Ref. 12]. Requirements for the ports of Jubail and Damman, Saudi Arabia fall under the auspices of The American Embassy in Riyadh, Saudi Arabia [Ref. 13]. Orders for Bahrain port calls are satisfied by the Administrative Support Unit, Southwest Asia (ADMINSUPU SWA), Bahrain [Ref. 14] Similarly, USDAO Riyadh, Saudi Arabia is the point of contact for orders placed for Jeddah, Saudi Arabia on the Red Sea [Ref. 15]. In all cases, the LOGREQs should be submitted at least ten days in advance of the anticipated arrival to port, via routine precedence Naval Message.

Units are expected to pick up and load all FFV orders in conjunction with port visits. The delivery to the pier is scheduled per the ship's request. However, in cases of operational necessity, shuttle via Combat Logistics Force (CLF) ships can be arranged. In these cases, there is a standing procedure for delivery to be made according to a fifteen day cycle. [Ref. 16] The pick up and delivery ship is assigned in the Logistics Replenishment message promulgated by ADMINSUPU, SWA. The customer ship still places an order using the NRCC contract in effect for the port that the shuttle ship is visiting. The procedure follows the normal order guidance, sending an information copy to the CLF ship. Actual dates for pick up by the shuttle ship and subsequent delivery to the customer ship via underway replenishment is promulgated via separate Naval messages.

b. Limitations

The nature of the indefinite delivery type contracts used results in concerns for customers that are not encountered with other contract types. For example, a vendor may try to "game" the system by quoting low prices on commodities with fewer orders or smaller quantities [Ref. 17]. When a ship orders a line item, they may be told that the commodity is not available, since the contractor does not necessarily want to process the items which yield a lower profit margin. This means that ships may not have all their requirements satisfied. In an attempt to alleviate this problem, NRCC detachment Bahrain instituted a policy where the contractor must notify them if a line item is not in stock [Ref. 17]. This allows NRCC to monitor contractor performance more closely.

c. Issues

Ships' schedules in this particular operating region are subject to change more frequently than in other operating areas due to current world situations. As a result, the ship does not always have time to verify the order and billing prior to departure from port when late-breaking schedule changes are made [Ref. 17]. Verification entails checking the actual commodities and quantities received against the billing invoice.

2. Sixth Fleet

a. Procedures

Units attached to the Sixth Fleet follow Commander, Service Force Sixth Fleet (CTF63) guidance for logistics support, including FFV. NRCC Naples oversees the specifics of procurement in the region, following up on contracts to ensure reasonable price and quality is obtained with on-time delivery. Comparison of price and quality being delivered to Naval vessels against what is available locally on the economy is the basis for determining satisfactory performance of the vendor. On-time delivery is measured by the comparison of actual delivery time against the ship's requested delivery time.

Current procedures require the ship to place an order for FFV when its LOGREQ is submitted. [Ref. 18] LOGREQs are submitted at least two days prior to entering port, but as soon as possible after receiving diplomatic clearance. A copy of the message is then sent to the husbanding agent, a local civilian contractor who is responsible for coordinating ship's requirements while in port.

The husbanding agent, in accordance with his/her contract, solicits three bids from local vendors interested in filling the order. [Ref. 19] The final decision on which vendor to use lies with the ship's Supply Officer. The Supply Officer reviews the quotes and determines which one best meets the ship's needs. The bid is selected, the vendor is notified and prepares the ship's order and delivers it to the ship. FFV is then loaded on board in conjunction with the scheduled stores onload during the port visit.

There is an exception to this policy. FFV for aircraft carriers and for units not able to enter port, due to operational requirements, have their FFV shuttled to them via a CLF ship. Loading is done based on schedule requirements and subsequent delivery is made to the customer ship. [Ref. 20] In these cases, customer units must submit their orders in advance of the shuttle ship port visit. Lead time is dependent upon the shuttle ship schedule. That is, selection of the shuttle ship and delivery schedule to the customer ship will be promulgated by CTF-63. As a general rule, additional lead time will be kept to a minimum. CTF-63 will try to schedule an underway replenishment (UNREP) as soon as feasible after the CLF loads commodities and goes back out to sea.

Shuttling typically entails an additional one to five days of cycle time from order to delivery via UNREP. Since there is no set lead time, ships must keep abreast of logistics planning messages when compiling orders to ensure proper order quantities within shelf life constraints. As a guide, customer ships can usually plan in advance, using the Logistics Replenishment (LOGREP) message promulgated by CTF-63 [Ref. 21]. This monthly Naval message designates customer ships and shuttle ships for each commodity. Using this, the Supply Officers from both units can work together to ensure customer ship requirements are filled.

b. Limitations

The procedure described above allows for maximum flexibility in the delivery of FFV to customer ships. Delivery of FFV to the pier is scheduled in accordance with the ship's request. That is, if a ship desires to receive FFV upon arrival, this is arranged. On the other hand, delivery on the morning of departure can also be arranged.

While the LOGREQ is the primary method for placing an order and some lead time is involved, ships may also add items to their order at any point during the cycle [Ref. 19]. There is, however, no guarantee that it can be filled. Port location normally dictates success in filling last minute requirements. Ports located close to growing regions such as Augusta Bay in Sicily are much more able to fill urgent requirements.

Product quality and shelf-life are major concerns when CLF ships shuttle FFV to customer ships. Additional handling is involved in the delivery and the FFV continues to age while in transit. Furthermore, the FFV is subjected to additional temperature fluctuations during the replenishment at sea operation. This is also a limitation in the Fifth and Seventh Fleet areas of operation.

Finally, quality is an issue at some port visit locations. While Mediterranean Sea ports typically offer a plentiful variety of FFV that is high in quality, this is not always the case in Black Sea ports [Ref. 19]. To compensate for this, DSCPE is sometimes utilized. They transport product to a supply ship stationed in the local region and then the FFV is transferred by the supply ship to the customer ship [Ref. 19].

c. Issues

Currently, DSCPE is conducting a Business Case Analysis to examine the feasibility and cost/benefit for them to provide FFV service in the Mediterranean. Any change in the current procedure must, at a very minimum, be transparent to customer ships and, preferably, should ensure a higher quality product at a better price.

3. Seventh Fleet

a. Procedures

Orders for FFV submitted by ships of the Seventh Fleet are handled in various ways. Ships operating out of Guam, Korea, Japan and Okinawa follow the set of procedures discussed below. Ships in other areas usually negotiate FFV procurement via NRCC Singapore contracts, husbanding agents and local procurement by the Supply Officer, coordinated through the USDAO or local shore activity.

Ships in the Pacific Rim currently place their orders through various commands, depending on the scheduled port visit. For visits to Guam, requirements are sent to COMNAVMARIANAS. Fleet Industrial Support Center (FISC), Yokosuka accepts orders for port visits in Japan. COMFLTACT Korea handles requirements for visits to Korea and NRCC Singapore manages requirements for Singapore visits. COMAUSNAVSUP handles requirements for Eastern Australia and COMSEVENTHFLTREP Western AS handles Western Australian port visits. The local USDAOs manage all other port requirements. [Ref. 22]. Lead time for the orders ranges from two weeks to thirty days. [Ref. 22].

For Guam, Korea and Japan, the respective command cited above consolidates the orders and places one order to DSO San Francisco. DSO San Francisco sends buyers to local terminal markets where the FFV is procured [Ref. 23]. From there, the FFV is delivered to the DSO warehouse, inspected, received and packaged for shipment. Controlled atmosphere technology is used in each container where it is felt that product might benefit from that service. The seavan containers are loaded onto a commercial vessel and shipped to the various countries. Upon arrival, the FFV is taken to a major distribution point, usually the FISC, where it is then sorted and delivered to customer units.

b. Limitations

Restrictions in some of the countries limit what may be imported from the United States. While this is an issue in all countries, some of the Pacific Rim countries have the most stringent requirements in the world. These restrictions will be discussed at greater length in Chapter IV.

Another issue that Seventh Fleet ships face is the lead time requirement and delivery schedule. Orders must be placed anywhere from fourteen to thirty days in advance of a port visit [Ref. 16]. Lead time is two weeks except for Guam and Okinawa, where it is thirty days [Ref. 22]. While the commissaries in the Pacific Rim receive supplemental shipments via airlift, troop issue is delivered by surface only [Ref. 23]. However, procurement is also made locally for small quantities, typically only enough to last until the next scheduled delivery from CONUS. As a general rule of thumb, the more lead time DSCP-PAC is provided, the more opportunities their buyers have to locate and purchase a particular commodity that satisfies quality requirements and subsequently will increase the range and availability of product lines.

A fifteen day shelf life, measured at time of delivery, is used for planning purposes in this region [Ref. 22]. For Guam, remaining shelf life at delivery is assumed to be ten days. As in the other regions, this is an important factor to consider when using CLF ships to shuttle FFV. For every day that the CLF holds the product without transfer, the customer ship has one less day of useful life. Shipboard Supply Officers need to be aware of this when placing orders.

Finally, temperature control is of concern at the FISC. To maintain commodities in optimal condition, they must be segregated by temperature. The FISC warehouse has only one room to hold all commodities combined [Ref. 23]. This may lead to increased respiration in some products, accelerated dehydration in others and surface damage and rot in yet others.

c. Issues

The method of order submission for FFV is changing. Within a few months, ships going to Guam, Korea and Japan will send their orders directly to DSO San Francisco via electronic means [Ref. 23]. The elimination of an order collection point will streamline the order input process and should reduce order lead time. DSO San Francisco operates according to a routine schedule of shipment and deliveries, and, as such, customers placing an order should have their orders shipped from CONUS four to six days after the order is received by DSO San Francisco. Combined with shipping time, order arrival will vary from 17 to 28 days after order placement, depending on country of delivery.

B. CUSTOMER SERVICE LEVELS

The identification of metrics to measure customer service levels proved to be an interesting task, as metrics were not well defined in any of the three geographic locations focused on during research. There are no major problems reported within the current arrangements. In fact, that was the general feeling conveyed during numerous interviews and correspondence.

When asked about customer service levels, each location responded differently. DSO San Francisco claimed a 90% customer service rate, which was defined by the percentage of commodity shipped arriving in acceptable condition [Ref. 23]. However, the largest category of customers for DSO San Francisco is represented by the commissaries, which do not adequately portray service levels to forward deployed units. The Commander, Logistics Western Pacific representative indicated that they assess customer service in terms of on-time arrival, order fulfillment and quality [Ref. 22]. Feedback is obtained from the ships via their after-action reports and no problems were evident. CTF-63 acknowledged that few complaints were received from their customers. When infrequent quality problems were identified they were typically the result of loss of shelf life from time of receipt by the shuttle ship until delivery to the customer ship. [Ref. 20] Additionally, contractors in this region did a reasonable job at fill rate and were consistently on time. The term "reasonable" was not quantified.

Throughout the course of this research, the authors attempted to find out how much FFV was lost due to spoilage. From a shipboard perspective, this proved to be a substantial task. Information was gathered from the Naval Supply Systems Command (NAVSUP) regarding total survey amounts of provisions as reported by individual units. However, NAVSUP does not maintain the individual surveys as they are primarily concerned with the total dollar value of loss and trends within ship classes. [Ref. 24] NAVSUP tracks how much total subsistence is surveyed and then analyzes the data by ship class to identify trends such as loss due to reefer failure that may indicate a systemic problem. Further discussion with various staffs indicated that each unit would have to be individually contacted to see what, if any, FFV spoiled and how much. This is partly due to the fact that no one compiles commodity-specific information and that losses in FFV are usually below the threshold necessary to complete a formal survey, unless the loss was due to a reefer failure. In minimal damage cases, detailed losses are reported as a "loss without survey" on internal shipboard documents. External to the ship, it is reported as a summary figure on food service returns. While no formal data collection regarding loss without survey commodities was done, at least one surface Type Commander estimated that fifty percent of the product reported on the loss without survey document is FFV. [Ref. 25] Assessment teams felt that these losses were due to over-ordering by the individual units. However, even this figure may be false since the informal survey indicates that most ships will simply "break out" damaged commodities rather than complete the paperwork to formally or informally write off their losses. This means that the fifty percent estimate may be low.

Discussion with various commands leads the authors to conclude that customer service is perceived to be adequate but not measured against any metrics. It is considered satisfactory because of the lack of complaints received by those providing the service. When problems do arise, they are addressed individually. No further attention is paid to the problems unless a trend is noted in a specific area. Customer service is treated as a by-product of the supply process. Each command responsible for ensuring ships have FFV pursue customer service passively, via a feedback loop only.

C. PRODUCT LINES RESEARCHED

The basis for determining applicability of CA/MA to forward deployed units was the establishment of a market basket common to all customers. To do this, research was conducted to identify the most demanded product lines.

The approach to finding the top product lines used by forward deployed customers was multifaceted. First, NAVSUP was contacted and summary data from their customers compiled. Second, all air and surface shipments to Pacific Rim customers ordered through DSO San Francisco were screened. Third, the Naval Regional Contracting Center (NRCC) Naples, Bahrain detachment was requested to provide their commodity usage data, as was NRCC Naples and CTF-63 and COMLOGWESTPAC.

The common commodity base of FFV ordered is measured by quantity or weight ordered. When the measurement used is total dollar value of all requisitions, the results are somewhat varied. This is predictable, however, due to the unique customers served in each geographic area. Measurement by total number of requisitions would not be valid due to shelf life considerations of commodities; those products with a shorter shelf life can be expected to be ordered more frequently and in smaller quantities. In general, ships will not order FFV with a short shelf life such as asparagus. Hence, the total weight measurement variable was chosen to identify top commodities. This is an important consideration from a cost analysis perspective.

Information acquired from NAVSUP includes all Navy customers [Ref. 24]. Compiled information includes 1997 second and third quarter requirements. Data summarized from DSO San Francisco includes all military customers, including commissaries, and represents July through December, 1997 demand [Ref. 23]. Specific commodity information is not maintained by either NRCC-Bahrain detachment, NRCC Naples or CTF-63. Therefore, review of commodities used in these areas was accomplished by using a sampling of invoices and Logistics Requirements messages from these regions and includes only Navy ships. However, review of this information indicates that the common market basket chosen also applies to units under their operating area.

Sourcing, as discussed more extensively in Chapter V is unique for each region. This explains the need for a multifaceted approach to FFV procurement. However, Appendices A, B, and C illustrate that geographic location, customer base and seasonality have little to do with commodities most commonly ordered. That is, the same commodities dominate the orders, regardless of who is ordering it, from where it is ordered or when it is ordered.

Based on the above, Table 1, illustrates the top commodities requisitioned by all Navy commands. Data review indicates that the use of NAVSUP 1059 data provides an accurate reflection of the most demanded commodities. Individual stock numbers for similar product lines have been combined to reflect a global perspective to the data. For example, onions with a two inch diameter have been combined with onions of a three inch diameter on Table 1. This was done to compensate for the local stock number and the item code assignment for similar products.

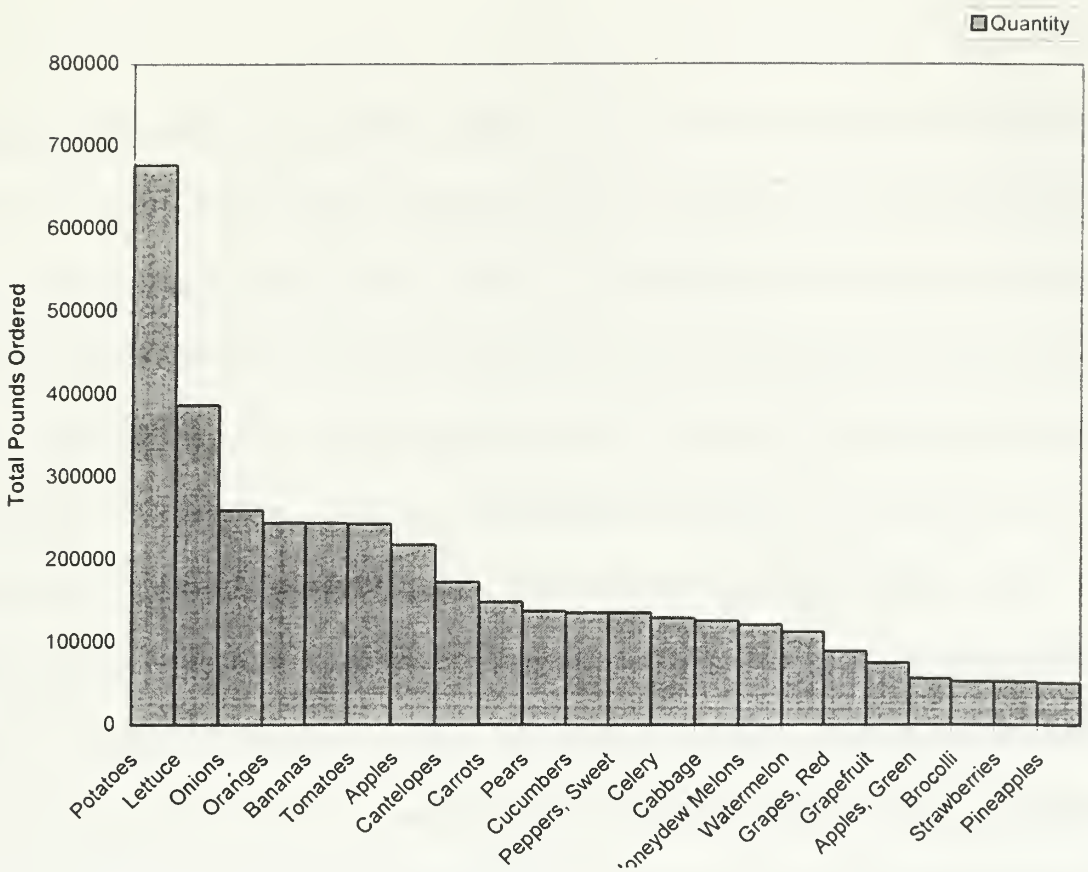

TABLE 1: COMMODITY USAGE BY WEIGHT

Table 1 defines the common market basket chosen as the basis for analysis within this thesis. Twenty-two commodities make up the market basket and represent the most-ordered line items of FFV in terms of weight.

D. ATMOSPHERE

The ability to alter a naturally occurring atmosphere and control it at a constant level has many advantages directly related to the transport and storage of fresh fruit and vegetables. Fresh fruit and vegetables are living plants and the naturally occurring metabolic processes continue after the commodity has been harvested from the plant. Oxygen is absorbed, and carbon dioxide, water, and heat are produced as the product continues to change physiologically. In order to enable a surface shipment in lieu of air transport and also enable the harvesting of the commodities at a "riper" stage to increase overall quality, it is desirable to transship using modified and controlled atmospheres.

The earth is surrounded by a layer of gases called the atmosphere. The atmosphere varies in temperature, weight and gas composition in relation to how close to the earth's surface (sea level) it is measured. At sea level the atmosphere exerts a pressure of 14.7 pounds per square inch (PSI) and decreases as altitude increases. [Ref. 26] The earth's atmosphere, at sea level, is composed of 78 percent nitrogen, 21 percent oxygen, and one percent of other miscellaneous gases such as argon, helium, neon, and carbon dioxide. [Ref. 26] Carbon dioxide comprises 0.03, or three one hundred's of the earth's atmosphere at sea level. [Ref. 26]

E. MODIFIED ATMOSPHERE

The term modified atmosphere, as it applies to this thesis, is the term associated with a packaging technique where the air or atmosphere inside a container is altered or modified from its naturally occurring composition. This is done to extend the shelf life of the commodity being packaged by placing it in an atmosphere that will slow the aging process and maintain freshness. MA can be used for up to ten days. [Ref. 27] A container may be a plastic package containing 12 (twelve) ounces of some commodity or it may be a 40 foot container capable of withstanding the rigors of a trans-oceanic voyage. The smaller packages are typically those that a consumer may buy in the local grocery store and are offered in commissaries as well. The atmosphere or air mix may be altered by introducing a high concentration of nitrogen into the container, thereby "forcing" out and lowering the oxygen content or it may involve introducing carbon dioxide to increase the total volume of that element in the atmosphere. The salient and unique characteristic of a modified atmosphere is that the atmosphere is altered or modified <u>once</u>. After the initial modification of the product's atmosphere, the container is sealed and the atmosphere is not altered or manipulated until the commodity reaches its destination.

F. CONTROLLED ATMOSPHERE

Controlled atmosphere is the alteration of the air surrounding a product and the <u>maintenance</u> of that atmosphere at a specified gas mixture for a finite period of time. Subjecting FFV to a controlled atmosphere will reduce losses by retarding senescence and damage. [Ref. 28]

Retarding senescence or aging is accomplished by reducing respiration, slowing ethylene production and the physiological softening of tissues. FFV sensitive to high levels of ethylene, will lose their sensitivity when oxygen levels are below eight percent. Reducing damage to FFV can be accomplished by inhibiting pathogens. Lower incidence of chill damage or commodities which develop other undesirable storage characteristics are effectively reduced with controlled atmosphere. In the aggregate, controlling the atmosphere will increase the shelf life of certain commodities and extend the marketability of FFV.

For the purposes of this project, controlled atmospheres will be categorized by the method in which they maintain the selected atmosphere, either passively or actively.

The ability of a system to add or continuously flush with nitrogen while in transit, and maintain oxygen and carbon dioxide at prescribed levels is the difference between an active and a passive CA system.

1. Passive System

The premier system utilizing passively controlled atmospheres is TECTROL produced and marketed by Trans FRESH Corp. The TECTROL process begins with a technician installing a plastic curtain in a track between the rear access doors and the commodity. This effectively seals the rear door area and enables the container to maintain its temperature and atmosphere with little variance. The container atmosphere is then purged with nitrogen which lowers the oxygen and carbon dioxide content to pre-determined levels. An electronic controller is then programmed by a technician to maintain the precise atmosphere specified for the commodity inside the container. The electronic controller is then attached directly to the container's access panel where it monitors, records, and controls oxygen content, carbon dioxide levels, temperature, and several other data sets. The controller maintains the atmosphere by two processes; as the product breathes, oxygen is used and carbon dioxide is produced. As the oxygen level is lowered, the controller activates a valve allowing outside air (21 percent oxygen) to enter the carrier, thereby increasing the overall level of oxygen. When the carbon dioxide level rises and reaches a pre-determined level the controller activates a carbon dioxide “scrubber”. A small fan is activated and pushes the container’s atmosphere through a hydrated lime filter bed, which absorbs the carbon dioxide in the airflow. This effectively reduces the container’s carbon dioxide level. The TECTROL system controls a container’s atmosphere passively through a combination of infusion of outside air and carbon dioxide elimination.

2. Active System

The Austrian firm Freshtainer offers the most sophisticated CA equipment that is available today. The system features a Pressure Swing Absorber (PSA) nitrogen separator, a carbon dioxide scrubber, and an ethylene scrubber. The PSA method functions as a molecular sieve, whereby ambient air is compressed and pushed through a carbon molecular sieve. The oxygen is removed from the airflow and nitrogen enriched air is directed to the storage container. [Ref. 29] This system controls the atmosphere by flushing the container with nitrogen, and removing excess carbon dioxide and ethylene.

Nitec is a privately owned manufacturing and service company that produces an active controlled atmosphere system. The heart of their active system is the air separation membranes that separate ambient air into its component elements. The oxygen and hydrogen elements of the ambient air are allowed to escape through the membrane leaving nearly pure nitrogen to pass into the storage container. The "mother unit" of this active system then controls a manifold system which can deliver dry nitrogen at purities up to 99.9% to ten individual containers simultaneously.

G. APPLICABILITY

As demonstrated graphically in Table 1, the top 22 commodities (by weight) utilized by naval forces both afloat and ashore have been compiled. Can the use of controlled atmosphere add value to any of these commodities? Figure 6 illustrates the benefits of applying controlled atmosphere technology to the market basket commodities.

H. APPLICABILITY OF CA TO COMMODITIES

The following section will describe the quality indices, the optimal temperature and relative humidity for CA storage and the potential for controlled atmosphere to add value to the particular commodity. Individual products will be discussed within groups divided by their ability to benefit by CA storage and Transshipment.

COMMODITY	APPLICABILITY	SHELF LIFE
POTATOES	LOW	180 - 240 DAYS
LETTUCE	MODERATE TO HIGH	21 - 28 DAYS
ONIONS	LOW	180 - 270 DAYS
ORANGES	MODERATE TO HIGH	56 - 84 DAYS
BANANA	HIGH	28 - 42 DAYS
TOMATOES	MODERATE TO HIGH	28 - 42 DAYS
APPLES	HIGH	28 - 56 DAYS
CANTELOPES	MODERATE TO HIGH	14 - 21 DAYS
CARROTS	LOW	60 - 270 DAYS
PEARS	HIGH	120 - 180 DAYS
CUCUMBERS	LOW	14 - 28 DAYS
SWEET PEPPERS	MODERATE	21 - 35 DAYS
CELERY	MODERATE TO HIGH	28 - 56 DAYS
CABBAGE	HIGH	60 - 180 DAYS
HONEYDEW MELONS	MODERATE TO HIGH	21 - 28 DAYS
WATERMELON	LOW	14 - 21 DAYS
RED GRAPES	HIGH	60 - 240 DAYS
GRAPEFRUIT	MODERATE TO HIGH	28 - 56 DAYS
GREEN APPLES	HIGH	120 - 240 DAYS
BROCOLLI	HIGH	21 - 28 DAYS
STRAWBERRIES	HIGH	21 - 28 DAYS
PINEAPPLES	HIGH	28 - 42 DAYS
LEMONS	HIGH	120 - 180 DAYS
WHITE GRAPES	HIGH	30 - 240 DAYS

FIGURE 6: APPLICABILITY OF CA TO COMMODITIES

Efficiencies in harvesting, ripening, and shipment methods are exploited as a direct result of controlled atmosphere and enable the product to be economically shipped anywhere in the world.

I. COMMODITIES WITH HIGH APPLICABILITY

The following commodities benefit to a high degree from shipment and storage in a controlled atmosphere.

1. Bananas

Controlled Atmospheres can extend the shelf life of bananas from four to six weeks. Bananas that are harvested mature-green and ripened on the plant often split and have poor texture when they reach the market. CA delays ripening and reduces respiration and ethylene production rates, enabling the picking of bananas at the full mature stage. [Ref. 30] Bananas are compatible for load-mixing with grapefruit, pears, and pineapples.

2. Apples

Apples stored and transshipped in CA maintain excellent consumer quality for four to eight months, depending on variety. Generally, a CA of one to two percent oxygen and zero to two percent carbon dioxide (atmospheres differ slightly among varieties) maintains the fruit's firmness and acidity and reduces the susceptibility to physiological disorders. [Ref. 31] Apples are compatible with pears, grapes and strawberries for load-mixing. However, their odor may be absorbed by cabbage, celery, carrots, figs, onions or potatoes.

3. Pears

Controlled atmospheres can extend the shelf life of pears from four to six months. CA storage of pears, Anjou, Bartlett, bosc and comice, generally consists of one to two percent oxygen and zero to one percent carbon dioxide and enables the varieties to maintain their capacity to ripen while attaining good flavor and texture. [Ref. 31] CA storage slows the rates of respiration, ethylene production, color change from green to yellow and softening of the fruits flesh. [Ref. 31] Pears are compatible with apples, grapes, strawberries and cantaloupe for load-mixing during transshipment.

4. Cabbage

Cabbage has the potential to be stored in CA with an extended shelf life of two to six months. An atmosphere consisting of two to three percent oxygen, three to six percent carbon dioxide and zero to five degrees Celsius will reduce color and trimming loss, delay and sprouting and inhibit root growth. [Ref. 28] Cabbage is compatible with broccoli, cauliflower, grapes, lettuce and oranges for mixed loads during transshipment.

5. Grapes

Controlled atmosphere can extend the shelf life of grapes from two to eight months. An atmosphere consisting of two to five percent oxygen and one to three percent carbon dioxide can extend the shelf life of grapes from eight weeks to six months, depending on variety. [Ref. 28] Grapes are compatible with apples, pears, strawberries and cantaloupe for load-mixing during transshipment. Grapes fumigated with sulfur dioxide produce an odor that can be absorbed by other fruits and vegetables.

6. Grapefruit

Controlled atmosphere storage can extend the shelf life of grapefruit from four to eight weeks. An atmosphere consisting of three to ten percent oxygen, and five to ten percent carbon dioxide offers the maximum benefit to most varieties of grapefruit. Grapefruit are compatible with lemons, oranges, pineapples and watermelon for load-mixing during transshipment. The odor from grapefruit treated with biphenyl may be absorbed by load mixed products and grapefruit may absorb odor from strongly scented fruits and vegetables, such as onions.

7. Broccoli

Controlled atmosphere can extend the shelf life of broccoli from 21 to 28 days. An atmosphere consisting of one to two percent oxygen and five to ten percent carbon dioxide is most beneficial for shipment and storage. However, broccoli is extremely sensitive to ethylene exposure and temperature control is critical to extended shelf lives. [Ref. 32] Broccoli is compatible with cabbage, lettuce, carrots and celery for load-mixing during transshipment.

8. Strawberries

Depending on the variety of strawberry and crop region of growth, CA can extend the shelf-life of this commodity up to 28 days. An atmosphere consisting of ten to fifteen percent carbon dioxide reduces the respiration rate of strawberries and reduces the growth of gray mold rot, the greatest cause of postharvest loss. [Ref. 31] Strawberries are compatible with apples, pears, grapes and cantaloupe for load-mixing during transshipment.

9. Pineapple

Controlled atmosphere storage and shipment of pineapples can extend the shelf life from four to six weeks. An atmosphere consisting of three to five percent oxygen and five to eight percent carbon dioxide will delay senescence and reduce the respiration rate of this product enabling harvest at a more mature stage. [Ref. 30] Pineapples are compatible with honeydew melons, lemons, oranges and watermelons for load-mixing during transshipments. However, pineapples absorb odors from avocados and bell peppers.

10. Lemons

Controlled atmosphere can extend the shelf life of lemons from four to six months. An atmosphere consisting of five to ten percent oxygen and zero to ten percent carbon dioxide reduce respiration and is accepted as the industry standard for long term shipment and storage. Lemons can withstand temperatures in the range of one to ten degrees Celsius for periods less than 30 days. [Ref. 28] Lemons are compatible with grapefruit, oranges, pineapple and watermelons for load-mixing during transshipment.

J. COMMODITIES WITH SIGNIFICANT APPLICABILITY

The following commodities significantly benefit from immersion in a controlled atmosphere. A benefit in addition to extended shelf life is the ability to mix loads with commodities that have a lower overall demand, thereby expanding the range of product offered to units forward deployed.

1. Lettuce

The use of CA enables logisticians to ship lettuce in containers over land or via surface maritime containers vice air shipment and extends the shelf life from 21 to 28 days, depending on the variety and region of commodity growth. A decreased oxygen atmosphere, one to three percent, and an elevated carbon dioxide mixture reduces senescence or aging, respiration of the product, and physiological disorders such as russet spotting. [Ref. 28] Great Lakes variety of lettuce has been successfully stored for seventy-five days under CA conditions. [Ref. 33] Lettuce is compatible with broccoli, cabbage, and oranges for transshipment and storage.

2. Oranges

Controlled atmosphere can extend the shelf life of oranges from eight to twelve weeks. Utilizing a CA of ten percent oxygen and five percent carbon dioxide, oranges can be harvested at late stages of maturity and "held" or harvested early and ripened under controlled conditions at destination, offering a high degree of flexibility for the grower / shipper. Oranges can be shipped anywhere in the world via surface mode if stored in a CA container, and are compatible for mixed load shipments with grapefruit, lemon, pineapple, watermelon, cantaloupe and honeydew melons.

3. Tomatoes

An additional shelf life of up to six weeks may be gained from using CA for tomatoes. A CA storage atmosphere of three percent oxygen and zero to three percent carbon dioxide, reduces ripening, respiration and ethylene production and is typically used to maintain acceptable consumer quality across a broad range of harvest maturity. [Ref. 32] Tomatoes are compatible for load-mixing with bananas, grapefruit and pineapples.

4. Cantaloupe

The utilization of controlled atmosphere can extend the shelf life of cantaloupes up to 21 days enabling surface transshipments vice airlift. A CA of three to five percent oxygen and ten to twenty percent carbon dioxide reduces ripening, respiration, sugar loss, ethylene production and the growth of surface molds. [Ref. 28] Cantaloupes are compatible with honeydew melons, oranges, and bell peppers for load-mixing for shipment.

5. Bell Peppers

Bell peppers gain an additional three to five weeks of shelf life through use of controlled atmosphere. CA conditions of two to five percent oxygen, and carbon dioxide and 7.5 degrees Celsius reduces respiration, ripening and ethylene production while maintaining the vegetables green color. [Ref. 28] Bell peppers are compatible with honeydew melons, lemons, oranges, tomatoes and watermelons. Bell peppers produce an odor that can be absorbed by beans, pineapple and avocados.

6. Celery

Controlled atmosphere can extend the shelf life of celery from four to eight weeks. Celery is a commodity that benefits from transshipment and storage in CA conditions of one to four percent oxygen and three to five percent carbon dioxide, which reduces respiration, senescence or aging, and discoloration caused by damaged tissue, and delay product decay development. [Ref. 28] The best utilization of celery under CA conditions is as a mixed load with lettuce.

7. Honeydew Melon

Controlled atmosphere can extend the shelf life of honeydew melons from 21 to 28 days demonstrated with excellent consumer grade quality. Generally, a CA of three percent oxygen, ten percent carbon dioxide and temperature of seven degrees Celsius will delay ripening, reduce respiration and inhibit the growth of molds and onset of decay. [Ref. 32] Honeydew melons are compatible with lemons, oranges, bell peppers, pineapples, tomatoes and watermelons for load-mixing during transshipment.

K. COMMODITIES THAT BENEFIT MARGINALLY

The remaining commodities from the market basket model benefit only marginally from controlled atmosphere conditions. These products are all low-value commodities that generally exhibit excellent shelf lives with temperature control alone.

1. Potato

Potatoes are a commodity that, with proper temperature control, will maintain consumer grade quality for six to eight months. The low price, wide availability and extended shelf life of potatoes do not generally make them a candidate for controlled atmosphere transshipment and storage. Potatoes do however mix extremely well with a number of products and will not be harmed by transshipping with a mixed load of tomatoes, watermelons, pineapples, bell pepper, oranges, lemons, honeydew melons, grapefruit, cucumbers and bananas. Odors from apples and pears can be absorbed by potatoes in any kind of storage, and should not be mixed.

2. Onion

Onions are a commodity that does not benefit appreciatively from storage in a controlled atmosphere. Onions can normally be stored up to nine months with proper refrigeration control. The low price, wide availability and extended shelf life of onions do not generally make them a candidate for controlled atmosphere transshipment and storage. Their generally accepted storage conditions and characteristics make them compatible for mixing with loads of tomatoes for transshipment. However, onions absorb odors from apples and pears and their odor will be absorbed by apples, pears, and celery if stored together. [Ref. 34]

3. Carrot

Carrots are a commodity that only marginally benefit from shipment or storage in a controlled atmosphere. Accurate storage temperature can extend shelf life from four weeks to nine months depending on the commodities maturity at harvest, offering excellent flexibility for the grower, shipper, and consumer. Certain conditions however, such as carbon dioxide concentrations above five percent and oxygen concentrations below three percent will generally result in increased pathological disorders. [Ref. 32] Carrots are compatible with cabbage, lettuce and cauliflower for load-mixing on transshipment. Carrot odors can be absorbed by celery.

4. Cucumber

Cucumbers also only receive marginal benefit from storage and shipment in a controlled atmosphere. Accurate temperature control is vital to this commodity as cucumbers are chill sensitive at temperatures below 10 degrees Celsius and benefit moderately with oxygen levels between three and five percent. [Ref. 28] Storage and shelf life does not generally exceed 28 days, however, cucumbers can be consolidated with bell peppers for mixed load transshipment.

5. Watermelon

Watermelon is a commodity that only marginally benefits from transshipment and storage in controlled atmosphere conditions. Precise temperature and relative humidity control are as effective as gas mixing to extend the shelf life of watermelon up to 21 days. [Ref. 34] Watermelon is compatible with grapefruit, lemon, oranges and pineapples for load-mixing during transshipment.

L. ETHYLENE CONTROL

As mentioned above, the hormone ethylene is emitted in a gaseous form and has a ripening effect on many commodities. Many commodities produce ethylene in the natural ripening process. This accelerates ripening even more, particularly in an enclosed space such as a container or refrigerated storage unit when controlled atmosphere to regulate internal gas composition is not used. There are products on the market which absorb the ethylene in an enclosed space without any further change to the atmosphere as done in a CA/MA environment that are of potential interest to DOD. These include ethylene absorbent blankets, filters, pillows and sachets.

1. Ethylene Absorbent Blankets

Ethylene absorbent blankets extract ethylene from the surrounding atmosphere. This is done by placing blankets in close proximity to circulating fans in the space. As air passes through the blanket material, it is scrubbed of ethylene. Useful life of a blanket is 45 to 90 days.

The Department of Defense has carried a stock numbered blanket for several years, national stock number 6850-01-303-1336. The particular blanket offered is manufactured by

Environmental Friendly Products, Incorporated. An article in Navy Food Service states that, during testing, submarines reported having lettuce lasting up to 70 days. Estimation of pounds of blankets required is according to the following formula:

Pounds of Blankets = Pounds of FFV X Number of Days Storage X .0001

Table 2 illustrates the number of pounds of blankets required for various combinations of storage time and weight carried. In Table 2, note that numbers of pounds of blankets required must be rounded up to the nearest integer. Most recent annual demand at the Defense Supply Center Richmond, the item manager for the blankets for DOD, was 525 packages. Of this, the Navy purchased approximately 400. [Ref. 35] The blanket currently carried in the supply system weighs ten pounds. Current price is $59.39 per package. Another company, Ethylene Control, Inc., manufactures two pound blankets. Conversation with both companies indicates that blankets may be manufactured at any size desired to accommodate space and weight requirements.

2. Sachets and Pillows

Sachets work in a similar manner to the blankets but are designed to be placed in individual boxes of FFV or smaller storage units and display cases. Ethylene Control, Inc. is the company that was researched for this market.

WEIGHT (LBS)	DAYS	LBS BLANKET	DAYS	LBS BLANKET	DAYS	LBS BLANKET
	Storage	Required	Storage	Required	Storage	Required
500	14	0.7	21	1.05	28	1.4
600	14	0.84	21	1.26	28	1.68
700	14	0.98	21	1.47	28	1.96
800	14	1.12	21	1.68	28	2.24
900	14	1.26	21	1.89	28	2.52
1000	14	1.4	21	2.1	28	2.8
1100	14	1.54	21	2.31	28	3.08
1200	14	1.68	21	2.52	28	3.36
1300	14	1.82	21	2.73	28	3.64
1400	14	1.96	21	2.94	28	3.92
1500	14	2.1	21	3.15	28	4.2
1600	14	2.24	21	3.36	28	4.48
1700	14	2.38	21	3.57	28	4.76
1800	14	2.52	21	3.78	28	5.04
1900	14	2.66	21	3.99	28	5.32
2000	14	2.8	21	4.2	28	5.6
2100	14	2.94	21	4.41	28	5.88
2200	14	3.08	21	4.62	28	6.16
2300	14	3.22	21	4.83	28	6.44
2400	14	3.36	21	5.04	28	6.72
2500	14	3.5	21	5.25	28	7
2600	14	3.64	21	5.46	28	7.28
2700	14	3.78	21	5.67	28	7.56
2800	14	3.92	21	5.88	28	7.84
2900	14	4.06	21	6.09	28	8.12
3000	14	4.2	21	6.3	28	8.4

TABLE 2: NUMBER OF POUNDS OF BLANKETS REQUIRED TO SUPPORT ETHYLENE CONTROL IN A REFIGERATED SPACE

They make three sizes of sachets: five gram for up to ten pound gross weight product, nine gram for up to 30 pounds and 40 gram sachets for display cases and reach-in reefers. The products researched that are manufactured by this company use potassium permanganate as the means for oxidizing ethylene. The mediums for injecting the potassium permanganate into the atmosphere include zeolite, which is essentially cat litter, or alumina. [Ref. 36] Environmental Friendly Products, Inc. uses injected alumina.

3. Filters

Ethylene Control, Inc. also offers several size filters to extract ethylene from a space. They offer two sizes of filters that are hung near the circulating fan in a space. The smaller size accommodates up to 3,000 cubic feet of FFV storage while the larger size is useful for up 10,000 cubic feet. In a sea container, filters extract up to 70 percent of the ethylene and last from one to two months.

M. CHAPTER SUMMARY

In summary, the Naval Operational fleets were defined by geographical Areas Of Responsibility, with the transfer of units between fleet commanders, Change Of Operating Areas, and forward deployment highlighted. The operational Fleet commander is responsible for logistical support and resupply of all units within his AOR, and the geographical or Fleet material distribution differences were discussed. The aggregate demand and usage of fresh fruit and vegetables was determined from Navy wide procurement figures and a model market basket was constructed utilizing the top 22 commodities based on total weight purchased. Controlled and modified atmospheres were defined, followed by descriptions of the most popular and applicable Commercial Off The Shelf (COTS) systems in use worldwide. The model market basket was then examined by individual commodity and determinations were made as to the applicability of controlled atmosphere, or the extent and potential for controlled atmosphere to add value to the transshipment of fresh fruit and vegetables to forward deployed forces. Finally, the use of ethylene absorbent materials on a stand alone basis was discussed along with sample material requirements per unit space and/or weight.

IV. SHIPMENT COST COMPARISON

A. COST ANALYSIS FOR DOD SHIPMENTS

There are many associated costs when shipping within the DOD environment. Computing the costs of an individual shipment is a complex task and not one often undertaken by the end use customer. Usually, the charges are submitted by each handling activity and the bills are paid through the Service Wide Transportation funds. The customer ordering a series of commodities rarely, if ever, sees the actual costs of shipping his order. The current system "isolates the customer from actual costs." [Ref. 37] Consequently, the customer may not be as concerned about costs incurred than he/she would be if he/she were actually paying the bill. For some customers, this could impact the shipping mode decision.

In his thesis titled, "Costs to Ship Fresh Fruits and Vegetables From Defense Subsistence Office Alameda Via Controlled Atmosphere Containers," LCDR Brenner conducted an in-depth discussion of the procedures used during that time frame (1994). While the methodology essentially remains the same, costs have changed due to regulations prohibiting working capital fund activities from making a profit and actual changes to the cost of commercial transportation contracts and CA services.

1. Cost Allocation

For each surface shipment, there are two costs computed. The first costs are referred to as green money costs or "limes." These are the actual charges the government pays to the contracted commercial carrier. The second set of costs are referred to as purple money costs or "plums" and include the actual costs to the government plus Military Traffic Management Command, Military Sealift Command and United States Transportation Command service charges. [Ref. 38]

Depending on who is providing, packing, and loading the FFV, there may also be additional handling charges. For example, MTMC offers a rate for packing seavans. This is not a service typically used by DSO San Francisco. The DSO chooses to hire its own contractor to perform this service and it is included in the DSCP surcharge. [Ref. 39] Also, the rate for applying CA to a container is now approximately $1050 per container without regard to the commodity. [Ref. 27] This is the rate paid by the shipping line to TransFresh. The government then pays the shipping line.

For ease of discussion, the basic case will be addressed. The actual cost to the government, the lime rate, is not of as much interest to the shipper as is the plum rate, the actual charges incurred to the Service Wide Transportation funds. Therefore, all discussion will be in terms of purple funds and will involve all applicable service charges associated with the shipment once it has reached the port of embarkation until it reaches the port of debarkation. This means that DSCP surcharges are not included. This was done to allow for a more meaningful comparison to commercial shipping rates.

Various route combinations that may be applicable to DOD refrigerated shipments were examined. MSC applies their container rate regardless of actual load factor. That is, the MSC rate applies evenly to an empty container or a full container. The basis for measurement is a standard forty foot seavan that holds up to fifty measurement tons (MTON). Rates are per MTON for a full seavan and are based upon routing. [Ref. 40] On the other hand, MTMC load rates and discharge rates are based on the amount of goods carried in the seavan. (Universal Service Contract, 1 February 1998) Thus, the total charge varies according to the load factor. Rates are based on billing area (there are six) and services provided. Rates are updated annually and listed in the Universal Service Contract issued by the Joint Traffic Management Office (JTMO). In the example rates given, the only services provided by MTMC were the loading and discharge of cargo at the carrier's terminal and billing for CA service. All stuffing and movement to the terminal is performed by another contractor, the equivalent of a third party logistics firm in the commercial sector. However, MTMC also controls billing of the CA portion so these rates are also included in the totals. The rates for CA service vary according to origin/destination pairs. Table 3 provides the sample rates, as computed from the Universal Service Contract that went into effect on 1 February 1998 and the MSC Container Rate Table that went into effect 1 October 1997. Sample rates for fifty percent, seventy-five percent and one hundred percent load factors are given.

Table 3 illustrates several points. First and foremost, it is always better to send a full container as the cost per unit measurement will be substantially less. Second, all charges for seavans leaving the East coast are the same, regardless of port, as are the charges for all ports in California. Therefore, it is more useful to look at transit times to the various ports of debarkation. This is discussed more in depth in the discussion of CA technology applications to DOD shipments in Chapter IV.

From	To	50% L.F.	75% L.F.	100% L.F.
California	Japan	$7,576.50	$7,892.25	$8,208.00
California	Korea	$8,254.00	$8,569.75	$8,885.50
California	Guam	$12,109.00	$12,424.75	$12,740.50
Charleston	Naples	$7,341.50	$7,657.25	$7,973.00
Charleston	Souda Bay	$7,341.50	$7,657.25	$7,973.00
Charleston	Catania	$7,341.50	$7,657.25	$7,973.00
Charleston	Dubai	$11,896.50	$12,212.25	$12,528.00
Charleston	Bahrain	$11,896.50	$12,212.25	$12,528.00
Charleston	Jebel Ali	$11,896.50	$12,212.25	$12,528.00
Baltimore	Naples	$7,341.50	$7,657.25	$7,973.00
Baltimore	Souda Bay	$7,341.50	$7,657.25	$7,973.00
Baltimore	Catania	$7,341.50	$7,657.25	$7,973.00
Baltimore	Dubai	$11,896.50	$12,212.25	$12,528.00
Baltimore	Bahrain	$11,896.50	$12,212.25	$12,528.00
Baltimore	Jebel Ali	$11,896.50	$12,212.25	$12,528.00
Norfolk	Naples	$7,341.50	$7,657.25	$7,973.00
Norfolk	Souda Bay	$7,341.50	$7,657.25	$7,973.00
Norfolk	Catania	$7,341.50	$7,657.25	$7,973.00
Norfolk	Dubai	$11,896.50	$12,212.25	$12,528.00
Norfolk	Bahrain	$11,896.50	$12,212.25	$12,528.00
Norfolk	Jebel Ali	$11,896.50	$12,212.25	$12,528.00

TABLE 3: DOD SHIPPING RATES FOR VARIOUS ORIGIN/DESTINATION PAIRS BY LOAD FACTOR (L.F.)

Finally, Table 3 only provides applicable charges for this fiscal year. Because the transportation component commands are working capital fund activities, their rates are permitted to fluctuate each year as their costs vary. In the case of MSC, the yearly rate has been increasing by up to twenty percent annually for the last five years. [Ref. 37] This variation makes it difficult to normalize the funding required for transportation.

B. COST ANALYSIS FOR COMMERCIAL SHIPMENTS

Similar to costs associated with maritime shipping in the Department Of Defense, there are a variety of costs associated with commercial maritime shipping. These costs include the basic rate, additional charges for services performed and ancillary rates.

The basic rate is the dollar amount charged to the shipper based on the specific commodity being shipped, actual weight of the commodity, point of origin, and point of destination.

A shipment is subject to additional charges when special services or handling is required. For example, a CA container incurs an additional shipping fee. Different rate schedules are levied depending on the type of container the commodity is being transported in. Typical container types are 20, 40, and 45 foot seavans. Containers that are refrigerated (chilled or frozen) are generally 50 to 100 percent more expensive to ship than a dry (non-referigerated) container.

Ancillary charges are often added to the cost of a shipment. These are other charges, levied above and beyond the basic rate. They include currency adjustment factors, fuel adjustment factors, terminal handling charges, and port congestion surcharges. Some specific examples of ancillary charges include:

- Currency Adjustment Factors; USA to Japan 39% of total; USA to Korea 0%; USA to United Arab Emirates 0%.

- Bunker Fuel Charges, also known as Fuel Adjustment Factor; USA to Japan, $6.00 per kiloton; USA to United Arab Emirates, $4.36 per kiloton; USA to Korea $120.00 per container.

- Terminal Handling Charges; U.S. East Coast $600.00 per container; U.S. West Coast included in most major shipping basic rates.

- Destination Handling Charges; Italy, $225 per container, United Arab Emirates $159.27 per container, Japan $115 per container, Korea $324 per container.

As the above examples illustrate, ancillary charges may be calculated as a percentage of the freight rate or a flat fee. In some cases, they may add a significant portion to the shipping bill.

In order to facilitate a more meaningful comparison to DOD rates, the same factors were applied to the rates in Table 4 as were applied to the rates in Table 3. These include a basic charge calculated using a generic fresh fruit commodity basic rate, a 40 foot refrigerated (chill) seavan container with a maximum payload of 57,059 lbs, shipped from origin container yard to destination container yard. Again, in these rates, the only services included are the actual loading and unloading of the container plus the transit.

C. ANALYSIS

The difference between rates paid by commercial shippers and the rate paid by the Service Wide Transportation Fund (SWT) in DOD varies markedly according to load factor and route. The SWT fund rate is calculated by the USC regional rate plus the surcharges added by MSC and MTMC. In this snapshot comparison, the commercial rates may be artificially high. That is because the rate for a single container, as shown in Table 3, does not receive any type of volume discount or loyalty discounts which DOD would certainly enjoy if DOD utilized commercial shipping exclusively.

From	To	50% L.F.	75 % L.F.	100 % L.F.
California	Japan	7218.80	7478.00	7737.60
California	Korea	7518.80	7778.00	8037.60
California	Guam	5056.73	6320.91	7901.15
Charleston	Naples	5099.77	5439.75	6799.69
Charleston	Souda Bay	5099.77	5439.75	6799.69
Charleston	Catania	5099.77	5439.75	6799.69
Charleston	Bahrain	8452.34	8650.28	11504.97
Charleston	Jebel Ali	8482.34	8680.28	11534.97
Charleston	Dubai	8482.34	8680.28	11534.97
Baltimore	Naples	5099.77	5439.75	6799.69
Baltimore	Souda Bay	5099.77	5439.75	6799.69
Baltimore	Catania	5099.77	5439.75	6799.69
Baltimore	Bahrain	8452.34	8650.28	11504.97
Baltimore	Jebel Ali	8482.34	8680.28	11534.97
Baltimore	Dubai	8482.34	8680.28	11534.97
Norfolk	Naples	5099.77	5439.75	6799.69
Norfolk	Souda Bay	5099.77	5439.75	6799.69
Norfolk	Catania	5099.77	5439.75	6799.69
Norfolk	Bahrain	8452.34	8650.28	11504.97
Norfolk	Jebel Ali	8482.34	8680.28	11534.97
Norfolk	Dubai	8482.34	8680.28	11534.97

TABLE 4:COMMERCIAL SHIPPING RATES FOR VARIOUS ORIGIN/DESTINATION PAIRS BY LOAD FACTOR (L.F.)

The actual aggregate cost savings would be more in line with the specific route of Oakland to Guam. In reality SeaLand and American President Lines (APL) handle all DOD shipping into Guam. During the voyage defined as container yard, Oakland, CA, to container yard, Apra Harbor, Guam, no DOD personnel handle the container or the commodity, yet MSC and MTMC still add their respective surcharge, apparently without adding any value to the shipment process. When both customers are shipping a container fully loaded (100% L.F.), the SWT fund achieves the closest match to what the civilian counterpart pays. This is likely the result of the MSC policy of charging for a full container, regardless of load factor. Another conclusion that may be drawn from comparing the rate tables is that the route directly influences rate differences between commercial and SWT fund rates.

D. CHAPTER SUMMARY

This chapter provided a discussion of the different costing methods applied to both DOD shipments and commercial shipments. Specific routes which could be used to ship FFV to forward deployed units were provided with cost estimates given for what the DOD shipper would pay vice the civilian counterpart for the same services. Finally, an analysis was provided, discussing the cost differences and likely reasons such differences exist.

V. APPLICATIONS TO FORWARD DEPLOYED FORCES

The current procedures used to provide forward deployed units with FFV was previously discussed. The question remains whether or not the technologies discussed in Chapter III can be applied to DoD shipments worldwide. The next discussion will answer this question. Discussion will include global sourcing, ideas for implementation of commercial technologies on board naval vessels, and ship-specific issues.

A. GLOBAL SOURCING

Fresh produce has become an increasingly important and desired commodity for the American consumer. The awareness of the benefits fresh fruit and vegetables offer to a balanced diet and resulting healthy lifestyle is a combination the Department of Defense both encourages and promotes. In the United States, fruit and vegetable consumption per capita rose 26 percent from 1978 to 1988 and consumer demand has forced fresh fruit and vegetable producers to offer both a higher variety of commodities and year-round availability. [Ref. 41]

The principle marketing channels for the U.S. fresh fruit and vegetable marketing system are:

- Food service establishments and institutions (of which DOD is one)
- Retail Food Stores
- Direct farmer to consumer sales.

Produce sold to institutional buyers (DSO) may be procured directly from shippers, brokers, or wholesalers operating in terminal markets or in independent warehouses in local communities. [Ref. 41]

Large volume purchases are transacted most effectively and efficiently by a direct sale and distribution at the production region. These "lot buys" enable an institutional buyer to eliminate inefficiencies associated with "middlemen", to take possession of the commodity as soon as possible following harvest, and to maintain optimum commodity quality indices throughout the shipment and storage period. Additionally it enables a partnership to be forged between the institution and the producer, fostering a mutually beneficial relationship that will lead to long-term efficiencies. Producer/shippers have responded to market pressures by consolidating operations, improving logistics operations and reaching across regional boundaries to satisfy year round demand for popular commodities. Specifically, lettuce producers in California's Salinas Valley commonly move operations in the winter to southeast California, southwest Arizona and Mexico in order to maintain a continuous year round supply of high quality lettuce. Many California and Florida shippers obtain products from other countries such as Ecuador and Chile during California's off-season, sometimes via joint ventures. This enables producers to extend shipping seasons and sell products produced in several locations via one marketing organization. [Ref. 41]

Terminal markets are another important point for the procurement of fresh fruit and vegetables. The primary vendors in terminal markets or terminal market operations are produce wholesalers who generally procure over half of their commodities directly from the producer. Produce wholesalers conduct a substantial amount of inter-wholesaler purchasing and can be utilized by the institutional buyer to balance short-order purchase requirements or procure small quantities of "niche" or specialty items, i.e., pumpkins during late September/early October. Terminal markets can be categorized regionally with terminal markets in the East and Midwest functioning as destination markets, serving small customers such as restaurants and independent retailers while terminal markets in primary production regions (California and Florida) serve institutional buyers and destination terminal markets.

Brokers and commission merchants are other players in the produce supply arena. Commission merchants purchase a commodity from a wholesaler and deliver it to the customer for a fee, hence the title. Brokers facilitate the "meeting" of producers with available product and customers with a demand and can negotiate an agreement for the transaction. Their fees are based on a percentage sales commission or flat fee per unit and are normally significantly lower than a commission merchant because the broker does not physically take custody or transport the purchased commodity.

The concept of global sourcing combines several unrelated principles that when consolidated could yield a global competitive advantage and substantial economic savings for the Department of Defense. The principles are:

- Controlled atmosphere. CA technology will extend the shelf life of commodities and enable the use of surface or maritime shipment in lieu of airlift.

- Laws of supply and demand. The United States is neither the top producer nor exporter of the majority of the researched fresh fruit and vegetable commodities utilized most often by Naval forces. Originating the shipment at the point of production closest to the end-use customer would enable the logistician to satisfy demand globally via surface or maritime shipment.

- Global competitive advantage. Purchasing commodities on the world market will be advantageous to the United States government in the vast majority of cases. High production yields combined with a historically very strong U.S. dollar, in comparison with foreign exchanges, will enable government buyers to get more value for every dollar spent and forge long-term strategic partnerships with grower/shippers at home and abroad. Appendix F contains the top ten countries in terms of production and export for each of the commodities in our market basket. A more detailed analysis of the individual products determines which commodities are candidates for global sourcing.

The following products are the prime candidates for a global sourcing initiative: lettuce, bananas, tomatoes, cantaloupes, cucumbers, celery, sweet peppers, honeydew melons, watermelons, grapefruit, broccoli, pineapples and strawberries. Figure 6 illustrates average maritime shipping times, based on regularly scheduled U.S. Flagged commercial liners, from global sourcing points of origin to distribution centers for the Fifth, Sixth and Seventh Fleets.

COMMODITY	Global Source Port of Origin	5TH Flt	6th Flt	7th Flt
Potatoes	Oakland, CA	32		15
	Rotterdam, Netherlands	20	6	29
Lettuce	Oakland, CA	32		15
	Barcelona, Spain	21	3	25
	Long Beach, CA	32		15
Oranges	Long Beach, CA	32		15
	Charleston, SC		20	
	Barcelona, Spain	21	3	25
Bananas	Manilla, Philippines		25	
	Ecuador	45	25	37
Tomatoes	Long Beach, CA	32		15
	Barcelona, Spain	21	3	25
	Aquaba, Jordan	19	7	20
Cantaloupes	Long Beach, CA	32		15
	Barcelona, Spain	21	3	25
	Izmir, Turkey	20	7	21
Cucumbers	Rotterdam, Netherlands	20	7	29
	Aquaba, Jordan	19	7	20
	Long Beach, CA	32		15
Sweet Peppers	Barcelona, Spain	21	3	25
	Long Beach, CA	32		15
	Izmir, Turkey	20	7	21
Watermelons	Barcelona, Spain	21	3	25
	Long Beach, CA	32		15
	Penang, Malaysia		22	15
Grapefruit	Long Beach, CA	32		15
	Charleston, SC			
	Haifa, Israel	20	7	21
Grapes	Naples, Italy	18	2	23
	Arica, Chile	40	27	37
	Long Beach, CA	32		15
Strawberries	Barcelona, Spain	21	3	25
	Oakland, CA	32		15
	Busan, Korea			
Pineapples	Manilla, Philippines		25	
	Limon, Costa Rica	40	30	36
Lemons	Long Beach, CA	32		15
	Barcelona, Spain	21	3	25

FIGURE 6: GLOBAL SOURCE SHIPPING TIME TO GENERIC PORT LOCATION IN FIFTH, SIXTH, AND SEVENTH FLEETS

The United States is the world's number one exporter of lettuce. For eight months of the year the majority of product is grown in central/northern California while in the four remaining winter months lettuce is grown in southern California, western Arizona and Mexico. DOD can resupply the world with controlled atmosphere shipments of lettuce, utilizing shipping points of Oakland and Long Beach, CA, and Barcelona, Spain, coinciding with the regions/seasons of lettuce production.

DOD can resupply forward deployed forces globally with fresh, high quality oranges utilizing strategic partnerships with growers in Spain, Florida and California. Oranges are a commodity that benefit greatly from controlled atmosphere shipment and storage, and can be shipped well within the product's shelf life cycle from Long Beach, CA, Charleston, SC, or Barcelona, Spain, to anywhere in the world.

Utilizing growing and shipping points of origin of Ecuador and Manila, Philippines the DOD can resupply forces worldwide with bananas in fourteen days or less, well within the capabilities of controlled atmosphere to maintain product quality. The strong U.S. dollar, "brand" growers

(Dole in the Philippines, Chiquita in Ecuador), and regularly scheduled container ship movements make this case a classic example of the efficiencies of global sourcing.

DOD can resupply forces worldwide with tomatoes and cantaloupes utilizing shipment points of Barcelona, Spain and Long Beach, California. Establishing strategic partnerships with growers in Spain and Mexico, and utilizing controlled atmosphere for shipment as storage will enable fresh, high quality product to be delivered globally with the desired fourteen days of shelf life or more remaining.

B. POTENTIAL APPLICATIONS TO NAVAL VESSELS

In addition to the efficiencies realized from the global sourcing of commodities, DOD can further exploit the capabilities of controlled atmospheres during the process of resupplying forward deployed forces.

Combat Logistics Fleet (CLF) vessels currently resupply naval units afloat by a process called Replenishment at Sea (RAS). During RAS, the CLF ship, the provider, and the receiving ship (customer) steam alongside each other on the same course and speed, separated laterally by 100 to 200 yards. Supplies are then transferred from the provider to the customer by helicopter (vertical replenishment or VERTREP) or a line, block and pulley arrangement (connected replenishment or CONREP). For example, CIMARRON Class oilers transfer fuel and stores simultaneously with the fuel held internally and the stores held in ten to fifteen reefer boxes secured to the deck. In this class of ship, the active CA system produced by NITEC could be substituted for the current reefer units used today. The result would be increased flexibility in scheduling underway replenishments (UNREPs) with the added benefit of fresher commodities being transferred to the customer ship. A longer shelf life would allow for more days storage on board the CLF unit and decrease the need for almost immediate UNREP of the customer ship. An additional benefit would be the ability of the CLF to carry more commodity: currently, CIMARRON class oilers do not typically reach maximum capacity to carry FFV. The limiting factor in the past has been freshness but this could be overcome by the use of CA. The result of this wholescale paradigm shift would be fresher, higher quality product delivered to forward deployed units, diminished loss and spoilage of product delivered to forward deployed units and the increased operational capability to support a more robust force with the same number of assets.

The NITEC system is the logical choice because of its ability to support 10 CA containers with a single "mother-unit". In the CIMARRON Class, the mother-unit could be located below decks, away from inclement weather with the supporting hoses and cables routed to the respective boxes on the weather deck.

Similarly, large combatants such as NIMITZ Class Aircraft Carriers and WASP Class Amphibious Assault Ships would be well suited to convert existing refrigerated storage compartment (reefer boxes) to an active CA storage boxes system.

Carrier Transicold, an international organization with headquarters in Syracuse, NY, produces and markets a "clip-on" CA system that is integral to a conventional refrigeration system. Their EverFresh™ system is an active membrane separator unit, that supplies nearly pure nitrogen, carbon dioxide, removes ethylene, and maintains temperature at a preset level. The entire unit is a comparable size to a refrigeration compressor / generator set and does not protrude into the cargo space diminishing container capacity. Additionally, a unique interlock safety system prevents the rear doors from being opened while the atmosphere inside the container is hazardous. A system like this would enable shipboard supply personnel to have "short-term" storage available for immediate access as well as holding stores in "long-term" CA storage, should operational tasking cause units to remain afloat longer than originally planned.

Permea Maritime Protection, an operating unit of Permea Inc., based in Austria, has recently developed and delivered PRISM controlled atmosphere systems to Dole Fresh Fruit International Ltd. for use in that company's fleet of cargo ships. The Permea systems are designed to deliver and control concentrations of nitrogen, oxygen, and carbon dioxide to product inside a ships hold. These shipboard specific units are the world's most technically advanced and consist of a 40 foot container which houses the system controller instrumentation, electrical connections, and gas interface connections. With a production capacity of one thousand cubic meters of enriched nitrogen per hour, this is the world's largest capacity system ever commercially installed. [Ref. 42] While current Naval vessels do not have the capacity to fully utilize these systems, the concept can be directly applied to current combatants, both large and small, as well as provide interesting ideas for the concept of sea-based logistics.

Expeditionary forces can also reap the benefits from "portable" CA containers. Once the beachhead has been established, and supply lines opened, expeditionary units ashore can be resupplied by commodities globally sourced, packed, and shipped in CA containers. With only a slight shift in the current paradigm of resupply, and operating with a fresh sea-based logistics philosophy, fresh fruits and vegetables can be as accessible to expeditionary forces as the current staple, Meals, Ready to Eat (MRE).

On smaller combatants, the use of CA is not practical. However, an inexpensive reliable method to reduce ethylene levels in a storage box is the addition of ethylene absorbing, blankets, filters or sachets. A single ethylene blanket, measuring 20 inches x 25 inches and produced by

Environmental Friendly Products, based in Texas, is advertised to reduce ethylene levels in 1000 cubic feet of cooler space for six months. As noted in Chapter III, many of the commodities in the market basket are highly sensitive to ethylene and commercially available ethylene absorption products could be incorporated into all FFV shipment and storage strategies. A larger blanket is already carried in the DoD supply system and used by some Navy ships but smaller ships may benefit more from some of the smaller, less bulky, lighter-weight alternatives in the form of sachets, pillows and filters.

C. SHIPBOARD ISSUES

1. Safety

Controlled Atmosphere shipments are not a panacea for all commodities shipped overseas despite the efficiencies and cost savings these systems offer. There is a potential for personal injury when proper procedures are not followed. These potential problems, however, are not insurmountable with current capabilities.

As discussed previously in Chapter 3, the CA gas mix utilized in shipment and storage is primarily nitrogen and will not sustain human life. Implicit in the adoption of CA shipment as a reliable transportation method is the training required for all personnel as to the potential danger of a CA container. Commercial shippers prohibit personnel from entering a CA container for 20 minutes after opening the container doors fully. This is a good starting point for DoD usage. Combining this commercial heuristic with the Naval capability of providing on-scene, gas-free engineers is a suitable compliment for safe operation. For example, in a CIMMARON Class resupply ship, the container doors must be opened for a minimum of 20 minutes and certified safe by a gas-free engineer, before personnel can enter and product can be moved out of the container.

In the case of a aircraft carrier or amphibious ship with a CA reefer box, the Carrier Transicold interlock system should be incorporated in every CA storage box. This would ensure a positive safety system is in place in addition to warning labels and the requisite safety training. Additionally, an emergency safeguard mechanism, like an oxygen flushing system similar to the standard shipboard main engine room (MER) halon flooding system, can be attached in addition to the gas free engineer certification to ensure personal safety while retrieving product from CA storage.

2. One Storage Unit

Many smaller ships only have one refrigerated storage unit in which to place all FFV, dairy, etc.. As a result, all products cannot be stored at the optimal temperatures desired for maximum longevity. The Naval Medical Command Publication 5010 specifies storage temperature for refrigerated commodities between .5 and 2.2 degrees Celsius. In the market basket being used, bell peppers, tomatoes, cucumbers, potatoes, pineapples, oranges and grapefruit all have temperature storage requirements outside of this range to maintain optimal freshness. Temperature is considered the single most important factor to maintaining quality product. As such, the benefit of any CA system used could be outweighed for these commodities by the damage caused by improper temperature storage. In this case, ethylene absorbent materials may be the preferred method.

D. MODELING LOGISTICS STRATEGY

The overall strategy of this logistics model is threefold; increase customer service levels, reduce the cost of resupplying forward deployed troops and increase the flexibility of the system to deal with contingency operations. Implementation of this strategy requires balancing a logistics triad: customer service, order cycle time, and transportation costs.

The focus of the logistics pipeline is the customer: get the highest quality product to the customer, when the customer needs it. The first leg of the triad is customer service.

Customer service must be an integral part of the planning strategy, not a by-product. It must be incorporated as a factor into decision-making instead of being driven by decision-making. Naval forces at sea and ashore have very predictable usage rates for perishable commodities such as FFV. Researchers have found that product availability and order cycle time are the most important factors affecting customer service. [Ref. 43] The concept of global sourcing virtually guarantees fresh, high quality FFV year round, with few exceptions. The DOD must utilize its resources, exploit the potential for economies of scale and forge partnerships with international growers/shippers to realize this potential. Doing this will result in a decreased order cycle time.

The second leg of the triad is order cycle time. Order cycle time is defined as "the elapsed time between the time a customer order, purchase order, or service request is placed and the time it is received by the customer". [Ref. 44] The limiting factor in the global sourcing model is the transportation time required to move commodities by surface. Utilizing global sourcing, the maximum transit from a source to the DoD customer is about 14 days and the use of forecasting can help mitigate that limitation. This is significantly shorter than the shipping times cited for the routes in Tables 1 and 2, which can exceed 30 days for some routes.

When demand is generated from many customers, most of whom individually purchase a small fraction of the total amount, the demand is said to be independent. [Ref. 44]

When demand is independent, statistical forecasting methods work extremely well and with historical data incorporated can be refined to a high degree of accuracy. DOD maintains data on FFV usage, but does not utilize that data in any meaningful way to forecast demand in an attempt to reduce order cycle time. This can and should be done.

Initiatives already undertaken and planned involving Electronic Data Interchange (EDI) such as the upcoming implementation of direct ordering for Seventh Fleet ships will also reduce order cycle time. Efficiencies gained by using EDI such as reduced cycle time should continue to be exploited in this area. Ordering, purchasing, and shipping schedules can be synthesized into an integrated logistics package.

The final leg of the triad is transportation costs. The goal in this area is to decrease transportation costs while ensuring a high quality product is still provided to the customer. The use of controlled atmosphere, shipped on regularly scheduled commercial lines and routes is fundamental to this strategy. In many instances, surface transportation may only be used if CA is also used.

Utilization of regularly scheduled commercial shipping is more efficient and reduces the cost of resupplying forward deployed forces. In cases where MSC and MTMC do not physically handle cargo, they should not impose a surcharge. Another equally important and cost-saving attribute of global sourcing is that the product is closer to the end-use customer and is not handled as often, lowering costs in terms of transportation charges and losses by handling and spoilage.

In the event of an urgent contingency operation, such as Somalia in 1992, Haiti in 1995 or Bosnia in 1996, a responsive, forward-thinking logistics organization can rapidly shift resources and tackle short-fused tasking. Managers of an agile system can brainstorm about the probability of events occurring that would "stretch" their organization and organize contingency plans that can be put into action quickly should the need arise. An agile, robust logistics system should become an integral piece of overall DOD contingency planning.

E. REVIEW

Global sourcing of FFV was introduced as a means of supply to Fifth, Sixth and Seventh Fleet units more directly. Potential applications of technologies to Naval vessels including outfitting CLF units and large combatants with CA boxes and equipment and use of ethylene absorbent materials for smaller ships were discussed. This discussion was followed by potential reasons not to employ the technologies including safety concerns and storage limitations. Finally, a model based on a triad of logistics issues to assist decision makers in determining strategy was introduced.

VI. CONCLUSIONS AND RECOMMENDATIONS

The data and information collected for this study on potential benefits of controlled atmosphere use for DoD shipments provides ample material to draw conclusions pertinent to the objective of this study and identify areas that warrant further research. This final chapter begins with conclusions and recommendations and ends with peripheral issues that are valid candidates for later research.

A. CONCLUSIONS

1. The use of global sourcing, controlled/modified atmosphere, and ethylene control products results in significant cost savings in the shipment of Fresh Fruit and Vegetables.

The potential cost savings are in the form of lower transportation costs, reduced loss of product due to spoilage, and reduced commodity damage due to handling.

2. The use of global sourcing and controlled atmosphere shipments will result in a fundamental paradigm shift with respect to the resupply of forward deployed troops.

The use of global sourcing and controlled atmosphere shipments will increase flexibility for scheduling logistics assets, enable logistics assets to transport a greater variety and quantity of FFV and more efficiently supply the warfighter.

B. RECOMMENDATIONS

1. Institutionalize the use of controlled atmosphere for DOD FFV shipment

The use of CA for FFV storage and shipment has been proven to save millions of dollars in transportation costs by moving products via surface maritime, prevent millions of dollars of product loss due to spoilage and ripening and significantly increase the product quality and commodity variety available to our customers. While CA is currently used to ship product from California to Pacific Rim customers, more widespread use would yield additional benefits for DoD customers.

2. Immediately begin a trial test of CA reefer boxes on Combat Logistics Force ships

The current practice of leasing reefer boxes and storing product onboard CLF ships can be easily transitioned to the lease of CA-equipped boxes for a regimented test period. A thorough test and evaluation period followed by a cost analysis will undoubtedly show significant operational as well as monetary benefits.

3. Form strategic partnerships with global shippers and producers for the purpose of sourcing commodities

The practice of procuring product as close as possible to the intended point of consumption will result in benefits through savings via economies of scale, lower transportation costs and reduced damage/loss due to handling and spoilage due to lengthy ship transit times.

4. End the practice of unilateral surcharges by DoD organizations that do not add value to the process

The current practice of adding surcharges to every shipment by MSC and MTMC significantly increase the transportation cost of shipment sometimes by 100%, without adding value to the process. MSC and MTMC, as organizations, both enable the process in some instances. The levy and payment of surcharges in those cases are certainly warranted. However, the unilateral charges are inefficient and expensive and effectively "hide" the real costs of resupply from the customer.

5. Compile usage data for the purpose of establishing a forecasting system

The establishment and implementation of a forecasting system will enable logistics planners to overcome the increased transit time of maritime shipping. Forecast data should be available for unit (ship) size concentrations all the way up to Battle Group size concentrations of forces.

6. Institutionalize the use of formal survey documents (DD Form 200) and Loss Without Survey Records as a metric for loss/spoilage of FFV

Loss of FFV due to spoilage or damage is not currently tracked as a singular item. The use of information in the DD 200 and Loss Without Survey records would enable planners to utilize a performance measure for tracking purposes and trend analysis, and would act as feedback mechanism for logisticians.

7. Incorporate a CA/MA/Ethylene Absorbency Module in the current Mess Management Specialist (MS) "A" and "C" Schools and Training pipeline

Although not discussed in this thesis, a training pipeline exists for the Mess Management Specialist rating. Introduction to methods available to preserve freshness of FFV at the earliest possible time in the training pipeline will result in an increased understanding of the entire process. In the end, this will yield a greater use of these methods and appreciation for what utilization can provide in terms of product quality and service to a dining facility patron.

8. Incorporate a CA/MA and Ethylene Absorbent Material Module in the Food Service syllabus of the Basic Qualification Course for Supply Officers

The Supply Officer Training pipeline, specifically the Basic Qualification Course, should similarly benefit from knowledge about the potential efficiencies of the use of CA/MA and ethylene absorbent material to the food service operation.

9. Include the University at California at Davis Post Harvest Outreach Program in training options

The Postharvest Outreach Program and Extension Programs should be mandatory training for all personnel involved in the purchasing, packing, shipping, distributing and processing/preparation of fresh fruit and vegetables. This particular course covers the latest methods and procedures being used in the commercial sector. Many of the corporate partners with whom DOD would team in the use of CA/MA contribute directly to and/or participate in this program. In addition to providing a beneficial learning environment for all involved, it would also serve as a catalyst for the exchange of ideas.

10. Institutionalize the use of ethylene absorbing material in shipboard storage of FFV

Ethylene absorbing material is currently available in the National Stock System. The expansion of the product line to include blankets, pads, sachets and filters should be accomplished as soon as possible. The current blanket in the system is bulky and contains more ethylene absorbing capabilities than some shipboard storerooms require. Other products in the commercial marketplace are lighter weight, easier to use and are manufactured for various size refrigerated units and product weights. In addition, on-the-job training and an aggressive information program should be implemented in order to exploit the full potential of these quality enhancing products.

11. Utilize "lightly processed" and MA prepackaged goods

The current market trend of lightly processed vegetables contained in individually modified atmosphere consumer packaging can be exploited efficiently by institutions such as the DOD. This new industry standard extends shelf life as well as reduces the labor requirements at the consumer level. Use of products such as prepackaged salad mixes will provide additional longevity of freshness with no additional investment.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

1. Distribution Center/Ripening Room

Conduct a cost/benefit analysis for the applicability of constructing a ripening room and FFV Distribution Center for each Forward Deployed Fleet. Such a center would enable the shipment and storage of non-ripe FFV. By using ethylene to advantage, these products could be ripened to meet demand as it occurs and ready-to-eat product would be forwarded to customers.

2. Validation of Temperature Charts for FFV in NAVMED Publication 5010

The current Navy Medical Command (NAVMED) standards are not in accordance with optimal storage temperatures for some commodities such as potatoes and tomatoes. Research should be conducted to determine if the tradeoff of product loss/damage would warrant new standards or utilization of different units of reefer storage.

3. Quantity and Benefit of Ethylene Absorbing Material in Shipboard Storage

Further study should attempt to document how much ethylene absorbing material is required for differing quantities of shipboard stored FFV. Additionally, how long the material is effective and commodity mix with an effective storage plan should be investigated. Delineation of information by ship class may enhance usage by the fleet.

4. DOD Surcharges and Value Adding

Research should be conducted to determine if the MTMC surcharge for booking a shipment on a commercial vessel is excessive or necessary. Additionally, the container surcharge by MSC should be evaluated as to whether it is currently viable or warranted given today's fiscal constraints.

APPENDIX A
FFV QUANTITIES DEMANDED
SUMMARY 1059 INFORMATION FROM ALL NAVY UNITS
2ND AND 3RD QUARTERS, 1997

FIC	NSN	NOMENCLATURE	UI	QUANTITY
W15	8915002528245	POTATOES,WHITE,BAKING TYPE	LB	357,647
W24	8915002264349	POTATOES, WHITE, 50 LB BG	LB	298,236
V69	8915009264926	LETTUCE,INDIVIDUALLY PACKAGED	LB	264,524
V11	8915001268748	BANANAS	LB	244,832
V89	8915001268804	ORANGES, EXCEPT TEMPLE	LB	244,248
W41	8915005824059	TOMATOES	LB	243,853
V03	8915010888749	APPLES, EATING, RED, SWEET	LB	218,513
V83	8915006160200	ONIONS, DRY, 2 INCH DIAMETER	LB	199,879
V18	8915001268801	CANTALOUPES	LB	173,517
V21	8915001278019	CARROTS	LB	149,209
V99	8915001268805	PEARS	LB	138,446
V42	8915002523788	CUCUMBERS	LB	136,408
V13	8915006160194	CABBAGE, DANISH	LB	126,678
V61	8915001274360	HONEYDEW MELONS	LB	122,058
V72	8915001173358	LETTUCE,NOT INDIV PACKAGED,DOMESTIC	LB	113,874
W50	8915000231508	WATERMELONS, 1 - 3 PER BOX	LB	113,118
V57	8915006160209	GRAPES, RED, SEEDLESS	LB	89,983
V54	8915006160198	GRAPEFRUIT	LB	75,550
V29	8915009264925	CELERY,INDIVIDUALLY PACKAGED	LB	72,819
W02	8915006160222	PEPPERS,SWEET,3 INCH DIA.(STUFFING)	LB	68,621
W03	8915001278006	PEPPERS,SWEET, 2 1/2 INCH DIAMETER	LB	67,747
V84	8915006160199	ONIONS,DRY,3 INCH DIAMETER,SPANISH	LB	60,469
V27	8915002523783	CELERY,NOT INDIVIDUALLY PACKAGED	LB	57,368
V01	8915001268812	APPLES, EATING, GREEN, SWEET	LB	55,979
V10	8915010821277	BROCCOLI	LB	53,459
W35	8915001277266	STRAWBERRIES	LB	53,351
W07	8915001268808	PINEAPPLE	LB	51,592
V67	8915005824071	LEMONS	LB	38,434
V58	8915006160028	GRAPES WHITE SEEDLESS	LB	36,833
V25	8915001277982	CAULIFLOWER	LB	34,444
V97	8915001278271	PEACHES	LB	32,766
W09	8915001268806	PLUMS	LB	31,026
V66	8915012598983	KIWIFRUIT	LB	30,801
W49	8915001268807	WATERMELONS, UNBOXED	LB	25,309
W43	8915001430978	TOMATOES, CHERRY	LB	24,556
W39	8915005824061	TANGERINES	LB	21,894
V04	8915010768439	APPLES, EATING, YELLOW	LB	21,662
W26	8915002743829	ROMAINE	LB	19,409
V78	8915011404612	MUSHROOMS	LB	19,120
W20	8915002264349	POTATOES,WHITE, 50 LB BAG	BG	18,197

V80	8915012653715	MANGOES, FRESH	LB	15,365
V79	8915002387120	NECTARINES	LB	13,384
V24	8915013232203	APPLES EATING RED TART	LB	10,345
V14	8915006160193	CABBAGE, RED	LB	10,089
V93	8915001278922	PARSLEY	LB	9,968
V56	8915001277987	GREENS, KALE	LB	9,022
V70	8915006160191	LETTUCE,NOT INDIVIDUALLY PACKAGED	LB	8,546
V74	8915001644161	LETTUCE,TABLE RDY,CHOPPED,DOMESTIC	LB	8,412
V09	8915001277268	AVOCADOS	LB	8,247
W21	8915006160027	RADISHES, RED, TOPPED	LB	8,171
W17	8915001491356	POTATOES,SHREDDED (HASH BROWN)	LB	7,604
V87	8915001277999	ONIONS, GREEN	LB	7,226
V92	8915012426689	PAPAYA	LB	6,232
V35	8915014075731	BROCCOLI FLOWERETTES, READY TO USE	LB	5,811
W12	8915013226827	POTATOES RED	LB	4,925
V32	8915002990335	CHERRIES, SWEET	LB	3,513
W16	8915004566111	POTATOES,WHITE,WHOLE, DOMESTIC	LB	3,490
V31	8915014075736	CARROTS, BABY, SLICED RTU	LB	3,097
V15	8915011392796	BEAN SPROUTS	LB	2,687
V28	8915014075753	CELERY, PASCAL, STICKS RTU	LB	2,675
V26	8915014075741	CAULIFLOWER FLOWERETTES RTU	LB	2,658
W34	8915013963993	SALAD, PREPARED, TOSSED SALAD, MIX	LB	2,532
W04	8915013996335	PEPPERS, SWEET, RED, SLICED RTU	LB	2,481
V16	8915004018478	CABBAGE, TABLE READY, DMST	LB	2,327
V85	8915013224684	ONIONS DRY RED	LB	2,309
V06	8915011415120	ALFALFA SPROUTS	LB	1,848
V75	8915001644160	LETTUCE,TABLE READY,WHOLE,DOMESTIC	LB	1,600
W25	8915014075789	ROMAINE, LETTUCE READY TO USE	LB	1,492
V73	8915013227447	LETUCE LEAF GREEN	LB	1,393
V81	8915002281947	ONIONS,DRY,PEELED,DOMESTIC	LB	1,300
V20	8915004831349	CARROTS,TABLE READY,DOMESTIC	LB	1,245
V05	8915001271861	APRICOTS	LB	1,212
W13	8915002281945	POTATOES,WHITE,DICED,DOMESTIC	LB	1,180
W33	8915005824065	SQUASH, SUMMER	LB	1,110
W30	8915001278014	SPINACH	LB	1,092
V02	8915001268811	APPLES, COOKING	LB	1,065
W10	8915013996775	PEPPERS, SWEET, YELLOW, RTU	LB	1,043
W37	8915004845964	TANGELOS, DOMESTIC	LB	984
V46	8915001277983	EGGPLANT	LB	908
W11	8915002525954	POTATOES, SWEET	LB	898
V48	8915001278904	ENDIVE	LB	874
V22	8915013232202	APPLES EATING GREEN TART	LB	865
V36	8915002525955	CORN, ON-THE-COB	LB	805
V90	8915006160211	ORANGES, TEMPLE	LB	772
W23	8915006160220	POTATOES, WHITE, 100 LB BAG	LB	746
V98	8915013232204	PEARS, BOSC	LB	705
V76	8915013227448	LETTUCE LEAF RED	LB	657

V52	8915008237663	GARLIC, DRY	LB	535
V50	8915001278905	ESCAROLE	LB	528
V30	8915014075777	CELERY, PASCAL, SLICED RTU	LB	510
W32	8915005842798	SQUASH,FALL AND WINTER	LB	458
V39	8915014169624	COLE SLAW MIX, R-T-U	LB	445
W22	8915004018479	RADISHES,WHOLE,TABLE READY,DOMESTIC	LB	435
W06	8915014075785	PEPPERS, SWEET, GRN, SLICED RTU	LB	355
V12	8915010668203	CABBAGE, CHINESE	LB	323
V33	8915013872416	CILANTRO	LB	323
V19	8915014075733	CABBAGE, RED,SHREDDED, READY TO USE	LB	315
V71	8915013226895	LETTUCE BOSTON	LB	304
W14	8915002281946	POTATOES,WHITE,FRENCH STYLE	LB	300
V77	8915001277260	LIMES	LB	286
W31	8915014075790	SPINACH, READY TO USE	LB	259
V86	8915004778418	ONIONS,GREEN,TABLE READY,DOMESTIC	LB	244
V07	8915001278015	ASPARAGUS	LB	184
W47	8915001278002	TURNIPS	LB	170
V91	8915014215317	PLANTAINS	LB	160
V55	8915001704933	GREENS, COLLARDS	LB	150
V17	8915012513222	BEANS, GREEN	LB	130
W08	8915014153833	PEA PODS,SNOW OR SUGAR SNAPS,R-T-U	LB	90
V23	8915001271875	CASABA MELONS	LB	75
V59	8915001709871	HONEYBALL MELONS	LB	70
W01	8915012661726	PEAS	LB	70
W05	8915001268745	PERSIAN MELONS	LB	50
V37	8915014075780	ENDIVE, READY TO USE	LB	44
V34	8915014075727	BEANS, GREEN, SNAP, READY-TO-USE	LB	30
W28	8915001279663	RUTABAGAS	LB	15
V44	8915002220753	DATES, PIECES, 8 - 12 OZ	LB	7

APPENDIX B
DEMAND AT DSO SAN FRANCISCO FOR FFV COMMODITIES
JUL - AUG 1997

Nomenclature	NSN	Total Weight
Oranges, 72s	891501S112754	712,635
Oranges, 88 ct.	8915001268804	531,755
Watermelon,12-22#	891500S111396	492,696
Orange, 56-72	891500S111379	367,040
Lettuce, Unwrapped	891501S112790	347,255
Grapes, Red SDLS Expo	891501S113329	315,306
Lettuce, Cello	891500S111443	302,310
Melon, Cantaloupe	891500S112324	294,695
Vidalia Onions	891501S112788	274,800
Watermelon, SDLS	891501S113687	247,755
Onion Dry Yellow	8915006160200	205,800
Grapes, White SDLS	891500S111365	190,234
Melon, Honeydew	891500S111927	175,575
Apple, red eat	8915010888749	168,760
Lettuce, Wrapped	8915009264926	164,670
Celery,Wrapped	891500S111423	130,785
Mango	891500S111372	106,730
Tomatoes, Pink 5x5	891500S112108	104,415
Cucumber, Med 25	891500S111781	99,100
Tomatoes, Greenhouse	891500S111709	86,595
Tomatoes, 4x5	891500S111709	81,195
Russet Potatoes	8915002264349	77,600
Apple, RD 5#	891501S113135	76,800
Peppers, Sweet Grn	891500S111899	61,730
Tomatoes, Pink Expo	891500S112108	59,580
Broccoli	891500S111413	52,200
Nectarine	891500S111374	44,465
Tomatoes, Greenhouse	891500S111939	41,310
Cherry, Swt	891500S111344	36,252
Green Beans	891500S111404	35,490
Strawberries	891500S111392	31,869
Peach, Freestone	891500S111382	25,640
Banana	891500S112032	24,360
Plums Rosa	891500S111388	23,000
Potato Bkg #10	891501S112937	20,250
Corn	891500S112512	18,240
Potato Russet	891501S112766	17,800
Potato Russet Sz a	891501S112936	17,050
Carrots, mini	891501S113408	16,380
Avocados, 40/48	891501S112744	11,362
Pomegranates, 24-36	891500S111389	11,025
Melon, Xmas/Sclau	891500S111346	8,838
Collard Greens	891500S112511	8,730
Banana Flower	891500S111791	8,275

Grapes, White	891500S112522	7,788
Cauliflower, wrapped	891500S111422	6,930
Pineapple	891500S112171	6,680
Plantains	891500S111906	5,050
Squash, Italian	891500S111496	4,940
Apple, R/D XF 72S	891501S112708	4,800
Apple, 40# RDEL 88ct	891501E210284	4,680
Grapes, Red	891500S111362	4,626
Romaine	891500S111795	4,170
Tangerine	891500S111395	3,275
Corn Golden	891500S112227	1,680
Potatoes White	891501S112997	1,550
Cranberries	891500S111348	1,422
Onion, Green	891500S111788	1,224
Cabbage, Green	891500S111778	900
Tomatoes, Green	891500S111565	500
Romaine	891500S111996	360
Mushroom, 8 oz	891500S111681	216
Bok Choy	891500S111403	160
Mushroom, Jumbo	891500S112222	120
Greens, Mustard	891500S111918	100
Tofu, Blue	894000S112588	18
F.E. Spinach Salad	891501S115179	14

APPENDIX C
SAMPLE DEMAND FOR FFV COMMODITIES BY SIXTH FLEET UNITS
CALENDAR YEAR 1997
SORTED IN DESCENDING DEMAND ORDER

Commodity	Total	Commodity	Total
Potatoes	5257	Cauliflower	937
Apples	4843	Watermelon	819
Lettuce	4069	Plums	769
Onions	3183	Broccoli	700
Tomatoes	3143	Eggplant	658
Oranges	3029	Apples, Yellow	550
Grapes	2774	Lemons	495
Cabbage	2573	Squash	479
Pears	2541	Tangerines	440
Bananas	2190	Strawberries	309
Cantaloupe	2151	Green Beans	305
Peppers	2111	Pears	301
Honeydew Melon	2096	Romaine	243
Celery	1747	Peaches	232
Carrots	1651	Mushrooms	191
Grapefruit	1353	Parsley	164
Kiwi	1099	Pineapple	118
Cherry Tomatoes	1044	Limes	110
Cucumbers	1000	Alfalfa Sprouts	44

APPENDIX D
COST COMPUTATIONS FOR DOD SHIPMENTS

MTMC	Load	Load	Load	Total	Total	Total	CA Cost
Discharge Rate	(MTONS)	(MTONS)	(MTONS)				
12.63	25	37.5	50	$7,576.50	$7,892.25	$8,208.00	1,600
12.63	25	37.5	50	$8,254.00	$8,569.75	$8,885.50	1,600
12.63	25	37.5	50	$12,109.00	$12,424.75	$12,740.50	1,600
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$7,341.50	$7,657.25	$7,973.00	1,500
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775
12.63	25	37.5	50	$11,896.50	$12,212.25	$12,528.00	1,775

APPENDIX E
EXCERPT DATABASE INFORMATION FOR MARKET BASKET COMMODITIES

Country	Product	Restrictions
Bahrain	Oranges and Grapefruit	Florida, Hawaii, Puerto Rico prohibited, Phytosanitary Certificate (PC) Required
	Bananas	None
	All others	PC
Oman	All others	PC
Qatar	All	No restrictions
Saudi Arabia	All	PC
UAE	All	No restrictions
Yemen	Grapes	Prohibited
	All others	PC, Import Permit (IP)
Australia	Onions	PC, IP. Only certain counties in CA, OR, ID. All other states prohibited. Statement of growth region and absence of Sclerotium Cepivorum.
	Celery	PC, IP. Must provide advance samples. Statement of absence of Psila Rosae.
	Watermelon	PC, IP. Statement about fruit fly declared areas of growth. Fumigated for melon fly.
	Oranges and Grapefruit	PC, IP. Fruit Fly statement. Free from quarantine pests. Addl restrictions for CA, TX, AZ . FL Prohibited
	Cantaloupe	PC, IP. Fruit Fly statement
	Cucumber	PC, IP. Fruit Fly statement.
	Carrot	PC. Prohibited from U.S.
	Strawberry	PC, IP. Fumigated with Methyl Bromide.
	Lettuce	PC, IP
	Tomato	Prohibited
	Apple	Prohibited
	Bananas	Prohibited
	Pear	Prohibited
	Potato	Prohibited
	Grapes	Prohibited
Japan	Celery	PC
	Broccoli	PC
	Cabbage	Prohibited from U.S.
	Bell Pepper	Prohibited from U.S.
	Watermelon	Prohibited from Hawaii, P.R., Virgin Islands. PC from FL and CA. Fruit Fly statement.
	Oranges and Grapefruit	PC. Fruit Fly statement. Prohibited from Hawaii, P.R., Virgin Islands.
	Cantaloupe	Prohibited from Hawaii, P.R., Virgin Islands. PC from FL and CA. Fruit Fly statement.
	Cucumber	Prohibited from Hawaii, P.R., Virgin Islands. PC from FL and CA. Fruit Fly statement.

	Carrots	PC
	Strawberry	Prohibited from Hawaii, P.R., Virgin Islands. PC from FL and CA. Fruit Fly Statement.
	Apple	PC from WA and OR. Only red delicious and golden delicious. Prohibited from all other states.
	Tomato	PC . Only certain varieties approved for entry. Fruit Fly statement.
	Bananas	Prohibited from Hawaii, P.R., CONUS
	Pear	Prohibited
	Potato	Prohibited
	Grapes	Prohibited from Hawaii, P.R., Virgin Islands. PC for other states. Fruit Fly statement.
Korea	Broccoli	Prohibited
	Cabbage	Prohibited
	Peppers	Prohibited
	Watermelon	Prohibited from Hawaii, P.R.. PC for other states. Addl requirements for CA, FL.
	Oranges and Grapefruit	Prohibited from Hawaii, P.R., Addl rqmts for CA, FL. PC for other states, Methyl bromide fumigation.
	Cucumber, Cantaloupe, and Honeydew	Prohibited from Hawaii, P.R.. Addl rqmts for CA, FL.
	Strawberry	Prohibited from P.R.. Federal PC for states. Fruit Fly statement. Addl rqmts for CA, FL.
	Tomato	Prohibited
	Apple	Prohibited
	Bananas	Prohibited from Hawaii, P.R.. PC for all other states.
	Pear	Prohibited from states and P.R.
	Grapes	PC required. Prohibited from Hawaii, P.R.. Addl rqmts for CA, FL.
Philippines	Peppers	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Oranges and Grapefruit	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Tomato	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Apple	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Bananas	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Pear	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
	Potato	PC, IP required
	Grapes	IP for FL, HI, TX. PC, IP for all other states. Philippine Plant Protection Service import number.
European Union	Onions	PC required
	Celery	PC required. Free from tomato spotted wilt virus.
	Broccoli, Cabbage,	PC required. Free from Thrips Palmi.

	Oranges and Grapefruit	PC required. Free from citrus canker, citrus black spot, peduncles. Packaging must show origin. Prohibited to Greece. Oranges prohibited to Italy.
	Cucumber, Honeydew, Watermelon	Unrestricted
	Strawberry	Unrestricted
	Lettuce	PC required. Free from tomato spotted wilt virus.
	Tomato	Unrestricted
	Apple	PC required. Free from quarantine pests
	Bananas	Unrestricted
	Pear	PC required. Free from quarantine pests.
	Potato	Prohibited
Turkey	Onions	PC required. Onion yellow dwarf statement.
	Celery	PC required. Free from tomato spotted wilt virus. Statement of Inspection.
	Broccoli, Cabbage	PC required. Free from soil and Coleoptera pests.
	Oranges, Grapefruit	PC required.
	Carrots	PC required. Free from soil and Coleoptera pests.
	Lettuce	PC required. Free from soil and Coleoptera pests.
	Apple	PC required
	Pear	PC required
	Potato	Prohibited

All information for this chart obtained from Mr. Tellson, U.S.D.A. Office, San Francisco, from the Purdue University EXCERPT Database. Current as of 1 February 1998.

APPENDIX F
WORLD FFV COMMODITY PRODUCTION AND EXPORT
1994 - 1996 WEIGHTED AVERAGE

APPLES

COUNTRY	PRODUCTION MTONS
China	16361700
United States	4742000
France	2297333
Turkey	2100000
Iran	1941356
Italy	1821061
Poland	1713430
Russia	1666667
Germany	1625000
Argentina	1215333

APPLES

COUNTRY	EXPORT MTONS
France	687433
United States	632724
Italy	445409
Netherlands	392931
Chile	380298
Bel-Lux	305109
New Zealand	242794
South Africa	216826
Iran	198664
Argentina	178535

BANANAS

COUNTRY	PRODUCTION MTONS
India	9934600
Brazil	6000660
Ecuador	5618848
Indonesia	4537724
Philippines	3296401
China	3038543
Costa Rica	2200000
Colombia	2100000
Mexico	2013175
Thailand	1750000

BANANAS

COUNTRY	EXPORT MTONS
Ecuador	3078777
Costa Rica	1737887
Colombia	1548166
Philippines	1174021
Panama	696791
Honduras	538183
Guatemala	531176
United States	387106
Mexico	201127
Cote Divoire	169837

BELL PEPPERS

COUNTRY	PRODUCTION MTONS
China	6345512
Turkey	1110000
Mexico	1024009
Nigeria	963333
Spain	847700
United States	597100
Indonesia	456666
Korea Rep	321333
Italy	303838
Bulgaria	262866

BELL PEPPERS

COUNTRY	EXPORT MTONS
Spain	282267
Netherlands	219854
Mexico	206269
United States	62819
Turkey	27283
Hungary	21686
Slovakia	14879
Italy	11682
Jordan	11491
Thailand	10890

CABBAGE

COUNTRY	PRODUCTION MTONS
China	15725820
Russian Fed	5238334
India	4200000
Korea Rep	3180000
Japan	2702000
United States	1835767
Poland	1832562
Indonesia	1641743
Ukraine	970666
Germany	837721

CABBAGE

COUNTRY	EXPORT MTONS
United States	176729
Netherlands	157036
Indonesia	69939
Spain	66760
China	58003
Italy	54996
Poland	31559
Germany	27134
Canada	25876
Malaysia	23774

CANTALOUPE

COUNTRY	PRODUCTION MTONS
China	5828978
Turkey	1800000
Iran	1215000
United States	962000
Spain	892300
Romania	641466
Egypt	466667
Italy	462384
Mexico	460938
Morocco	415200

CANTALOUPES

COUNTRY	EXPORT MTONS
Spain	241206
United States	126702
Mexico	121722
Costa Rica	92010
Honduras	73185
Brazil	57879
France	38163
Netherlands	25803
Panama	19326
Israel	17912

CARROTS

COUNTRY	PRODUCTION MTONS
China	4172846
United States	1692177
Russian Fed	1446667
Poland	796103
Japan	724000
France	641990
United Kingdom	630100
Netherlands	430000
Italy	382063
Ukraine	351000

CARROTS

COUNTRY	EXPORT MTONS
Netherlands	200872
Italy	107500
Bel-Lux	99270
United States	83769
France	62403
Canada	59138
Spain	51435
Australia	34754
China	25847
United Kingdom	24291

CUCUMBER

COUNTRY	PRODUCTION MTONS
China	13058880
Iran	1262040
Turkey	1150000
United States	991353
Japan	826400
Ukraine	683666
Netherlands	480000
Korea Rep	357000
Iraq	341666
Indonesia	310000

CUCUMBER

COUNTRY	EXPORT MTONS
Netherlands	431990
Mexico	242922
Spain	208541
United States	45671
Bel-Lux	33904
Jordan	30721
Malaysia	25267
Greece	25251
Romania	17359
Syria	12199

GRAPEFRUIT

COUNTRY	PRODUCTION MTONS
United States	2575800
Israel	391083
Cuba	261375
China	212333
Mexico	185444
Argentina	175977
South Africa	161212
India	90000
Iran	64596
Sudan	64333

GRAPEFRUIT

COUNTRY	EXPORT MTONS
United States	472591
Israel	105252
Cuba	88333
South Africa	84912
Bel-Lux	71232
Netherlands	62764
Turkey	39322
Cyprus	38686
Argentina	30720
Spain	19068

GRAPES

COUNTRY	PRODUCTION MTONS
Italy	8668113
France	7304750
United States	5842200
Spain	4472834
Turkey	3550000
Argentina	2311533
China	2028962
Iran	1881911
South Africa	1666667
Chile	1595327

GRAPES

COUNTRY	EXPORT MTONS
Italy	592981
Chile	447242
United States	257194
Spain	103431
South Africa	95700
Greece	94286
Netherlands	59847
Mexico	56469
Bel-Lux	36678
Turkey	24663

LEMONS / LIMES

COUNTRY	PRODUCTION MTONS
Mexico	1001349
India	980000
United States	865166
Argentina	788752
Iran	678548
Italy	615467
Brazil	495000
Spain	435200
Turkey	356000
Egypt	322515

LEMONS / LIMES

COUNTRY	EXPORT MTONS
Spain	380500
Mexico	141933
Turkey	132292
United States	131948
Argentina	79309
Netherlands	62274
Greece	51289
Italy	41785
South Africa	29646
Uruguay	22448

LETTUCE

COUNTRY	PRODUCTION MTONS
China	5133334
United States	3777333
Spain	931966
Italy	862786
India	760000
Japan	536400
France	523874
United Kingdom	218900
Turkey	215000
Bel-Lux	177164

LETTUCE

COUNTRY	EXPORT MTONS
United States	300069
Spain	263885
Netherlands	117553
Italy	114486
Bel-Lux	86492
France	75704
Mexico	20457
China	14250
Lebanon	14000
Canada	8406

ONIONS, DRY

COUNTRY	PRODUCTION MTONS
China	9288228
India	4219300
United States	2832217
Turkey	2216667
Japan	1278000
Iran	1176824
Pakistan	1072224
Spain	991766
Brazil	935265
Russian Fed	710000

ONIONS, DRY

COUNTRY	EXPORT MTONS
Netherlands	543377
India	370094
United States	294365
Spain	239432
Argentina	139841
Poland	129891
Egypt	127979
Turkey	94702
Iran	70075
United Arab Emirates	69333

ORANGES

COUNTRY	PRODUCTION MTONS
Brazil	21069000
United States	10846670
Mexico	2371774
Spain	2302667
China	2232909
India	2080000
Italy	1900316
Egypt	1590341
Iran	1585307
Pakistan	1377200

ORANGES

COUNTRY	EXPORT MTONS
Spain	1391521
United States	562481
Greece	411098
South Africa	371998
Morocco	294192
Israel	149338
Netherlands	148258
Italy	140366
Brazil	114741
Uruguay	90280

PEARS

COUNTRY	PRODUCTION MTONS
China	5697559
United States	843313
Italy	820744
Spain	580266
Argentina	493666
Japan	426000
Turkey	410000
Germany	351000
France	316074
Turkey	250000

PEARS

COUNTRY	EXPORT MTONS
Argentina	169066
Chile	150079
United States	143934
Italy	137139
Netherlands	134194
Bel-Lux	130677
South Africa	94188
China	85720
France	70775
Spain	61832

PINEAPPLES

COUNTRY	PRODUCTION MTONS
Thailand	2049870
Brazil	1591349
Philippines	1474185
China	849685
India	830000
Nigeria	800000
Indonesia	727058
Colombia	387000
United States	314333
Mexico	294664

PINEAPPLES

COUNTRY	EXPORT MTONS
Philippines	159789
Costa Rica	145063
Cote Divoire	131986
Bel-Lux	47826
Honduras	47160
France	38492
Dominican Republic	26751
Brazil	22936
Malaysia	21602
United States	17376

POTATOES

COUNTRY	PRODUCTION MTONS
China	47940200
Russian Fed	39476330
Poland	26441780
United States	21413000
India	18314130
Ukraine	17379670
Germany	12529930
Belarus	10628170
Netherlands	7834000
France	6209966

POTATOES

COUNTRY	EXPORT MTONS
Netherlands	1886033
Bel-Lux	856486
Germany	768069
France	678193
Canada	484863
Italy	297053
United States	269061
Turkey	192243
Poland	182767
United Kingdom	181046

STRAWBERRIES

COUNTRY	PRODUCTION MTONS
United States	734966
Spain	246200
Japan	201500
Poland	177500
Korea Rep	171000
Italy	169566
Mexico	128207
Russian Fed	117333
France	75578
Germany	68698

STRAWBERRIES

COUNTRY	EXPORT MTONS
Spain	161520
Italy	61413
United States	51594
Bel-Lux	23764
Mexico	20105
Poland	17230
Netherlands	14989
France	12173
Morocco	7170
Russian Fed	3418

TOMATOES

COUNTRY	PRODUCTION MTONS
China	15029110
United States	11706330
Turkey	7283334
Italy	5655204
Egypt	5036712
India	5000000
Spain	3139200
Brazil	2686823
Iran	2234456
Mexico	2040942

TOMATOES

COUNTRY	EXPORT MTONS
Netherlands	697707
Spain	657677
Mexico	554824
Bel-Lux	225786
United States	164994
Morocco	156484
Jordan	121127
Turkey	97255
Italy	83125
France	77368

WATERMELONS

COUNTRY	PRODUCTION MTONS
CHINA	21301510
TURKEY	3600000
IRAN	2650000
UNITED STATES	1852000
KOREA REP	1056333
GEORGIA	766666
EGYPT	726666
SPAIN	706266
GREECE	651806
JAPAN	616500

WATERMELONS

COUNTRY	EXPORT MTONS
Spain	231783
Mexico	142552
Greece	138792
United States	113119
Malaysia	105814
Italy	92423
Guatemala	49459
Hungary	35110
Singapore	34370
China	30548

APPENDIX G
COMPATIBLE FRESH FRUIT AND VEGETABLE GROUPS

Group 1A - Vegetables
32° - 36° F, 7 Day Storage

alfalfa sprouts	Chinese cabbage	mint
amaranth	Chinese turnip	mushroom
anise	collard*	mustard greens*
artichoke	corn,sweet,baby	parsley*
asparagus*	endive*	radicchio
beans,lima	escarole*	radish
bean sprouts	fennel	rutabaga
beet	garlic	rhubarb
bok choy	green onion*	shallot
broccoli*	herbs*	snow pea*
brussel sprouts*	sweet pea*	spinach*
cabbage*	turnip	carrot*
kale	turnip greens*	cauliflower*
leek*	waterchestnut	celery*
lettuce*	watercress	chard*

* Products marked with an asterisk are sensitive to ethylene damage.

Group 1B - Fresh Fruit
32° - 36° F, 7 Day Storage

apple	fig	prune
apricot	gooseberry	raspberry
avocado	grape	strawberry
blackberry	kiwifruit*	blueberry
loganberry	boysenberry	cantaloupe
cherry	peach	nectarine
pear	currant	coconut
cut fruits	plum	date

* Products marked with an asterisk are sensitive to ethylene damage

Group 2 - Vegetables
45° - 50° F, 7 Day Storage

basil	beans, snap, green, wax	cactus leaves
calabaza	chayote*	pea, southern
cucumber*	eggplant*	kiwano
malanga	okra*	pepper, bell, chili
squash, summer		tomatillo

*Products marked with an asterisk are sensitive to ethylene damage.

Group 2 - Fresh Fruit
45° - 50° F, 7 Day Storage

avocado	cactus pear	carambola
cranberry	custard apple	grapefruit*
guava	kumquat	lemon*
lime*	mandarin	olive
orange	passion fruit	pineapple
sugar apple	tamarillo	tamarind
tangelo	watermelon	

* Products marked with an asterisk are sensitive to ethylene damage.

Group 3 - Vegetables
55° - 65° F, 7 Day Storage

bitter melon	boniato
cassava	dry onion
ginger	jicama
potato	pumpkin squash*
sweet potato*	taro
tomato	yam*

* Products marked with an asterisk are sensitive to ethylene damage.

Group 3 - Fruits
55° - 65° F, 7 Day Storage

banana	breadfruit
canister	casaba melon
Persian melon	honeydew melon
mango	papaya
plantain	

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